APRIL 1957

ie

ILLUMINATING ENGINEERING

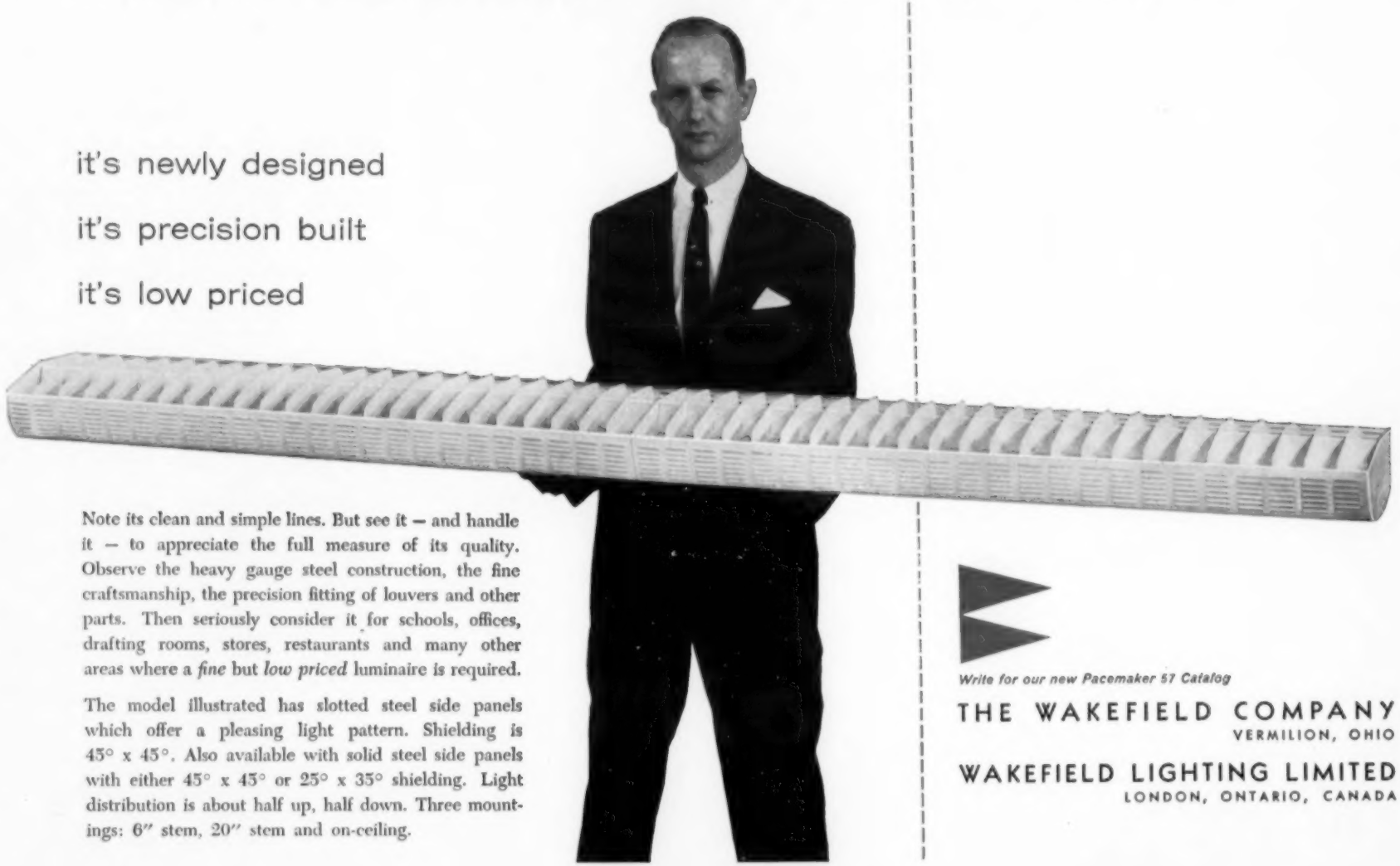
Journal of the
ILLUMINATING ENGINEERING SOCIETY

Presenting **PACEMAKER 57** *by Wakefield*

it's newly designed

it's precision built

it's low priced



Note its clean and simple lines. But see it — and handle it — to appreciate the full measure of its quality. Observe the heavy gauge steel construction, the fine craftsmanship, the precision fitting of louvers and other parts. Then seriously consider it for schools, offices, drafting rooms, stores, restaurants and many other areas where a *fine* but *low priced* luminaire is required.

The model illustrated has slotted steel side panels which offer a pleasing light pattern. Shielding is 45° x 45°. Also available with solid steel side panels with either 45° x 45° or 25° x 35° shielding. Light distribution is about half up, half down. Three mountings: 6″ stem, 20″ stem and on-ceiling.

Write for our new Pacemaker 57 Catalog

THE WAKEFIELD COMPANY
VERMILION, OHIO

WAKEFIELD LIGHTING LIMITED
LONDON, ONTARIO, CANADA

...a new lighting development from *Smithcraft*

Smithcraft TWOSOME with brand new COMPOUND SHIELDING

45° x 45° SHIELDING IN A VERY SHALLOW UNIT WITH NO DARK CENTER STREAK

Quality, beauty, and comfort are combined in the new top value, low-cost Smithcraft TWOSOME. The new Smithcraft Compound Shielding permits the comfort benefits of 45° x 45° shielding in a very shallow unit (only 3½" deep). *And there is no dark center streak!* This Compound Shielding is a center strip of extruded Polystyrene with white steel baffles on either side . . . very interesting and eye-pleasing. Bottom shielding and side shields are one complete assembly which hinges from either side or may be easily removed entirely.

For two or four 4' or 8' lamps, TWOSOME may be also specified with Plastic Louvers (42° x 42° shielding), Ribbed Skytex Glass, or Flanged Polystyrene (impact resistant). Ask the man from Smithcraft to tell you more about the TWOSOME for schools, offices, stores or similar installations.

Harry R. Wolf, Jr., Philadelphia Representative, one of Smithcraft's nationwide sales organization.

. . . . . the man from *Smithcraft*

He's a man who knows lighting "from the architectural standpoint". Because he talks "*lighting*" rather than "fixtures", he can help you find the time-saving, economical solutions to lighting problems that are posed by any building design on your boards. Call him in to consult with you or your lighting engineers on the TWOSOME or any one of the Smithcraft line of lighting units.

Smithcraft fluorescent lighting units are installed in thousands of offices, factories, schools, stores and diversified interiors from coast to coast. Wherever good lighting is important, you'll find . . .

SMITHCRAFT — "AMERICA'S FINEST FLUORESCENT LIGHTING"

Smithcraft
LIGHTING
CHELSEA 50, MASSACHUSETTS

PLEASE ATTACH TO YOUR BUSINESS LETTERHEAD and mail to *Smithcraft* LIGHTING, CHELSEA 50, MASS.

NAME _____

TITLE _____ CO. _____

ADDRESS _____ CITY _____ STATE _____

☐ Please send me the monthly publication, "Light Side of the News", so that I can keep in touch with the latest trends in lighting.

☐ Please send me the "TWOSOME" Folder and catalog sheets.

☐ Please send me the complete SMITHCRAFT CATALOG, containing data on America's Finest Fluorescent Equipment.

Two Ballast Lives for the Price of One!

STARRING'S

RAPID-START RS-240-C Ballast

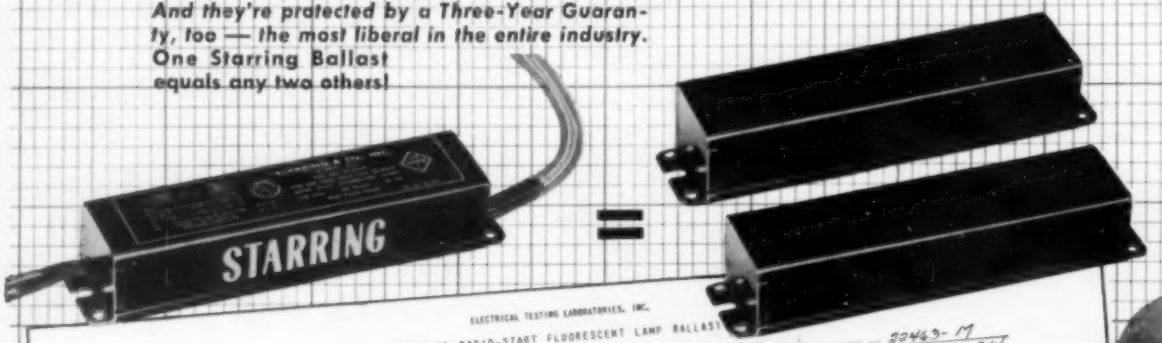
for two 40-Watt Lamps on 118-Volt Lines

Cooler by Design — Cooler through Construction — COOLER IN USE!

Lower Operating Temperature means Longer Service Life. No ballast for similar service is smaller . . . none is quieter . . . and ETL tests show the low temperature rise of the RS-240-C—an average of only 47.5°C against the industry-standard maximum of 65°C!

And they're protected by a Three-Year Guaranty, too — the most liberal in the entire industry.

One Starring Ballast equals any two others!



RS-240-C
8 3/16" x 2 5/16" x 1 11/16"
Mounting Length 8 57/64"
Weight 3.9 pounds
Packed 15 per Carton

CBM CERTIFIED

UL

Ask for our Complete Catalog

STARRING & COMPANY, INC.

1600 SEAVIEW AVE BRIDGEPORT 8, CONN EDison 4-0108

ie

ILLUMINATING ENGINEERING

THE JOURNAL OF THE ILLUMINATING ENGINEERING SOCIETY

April
1957

Vol. LII, No. 4

1956-1957 Officers

President
M. N. Waterman

Vice-President
Kirk M. Reid

Vice-President
George J. Taylor

General Secretary
R. G. Sleuer

Treasurer
J. B. Browder

•

Editor
Ruby Redford

•

Advertising Manager
Clayton E. Ellis

•

Assistants
Barbara Lamson, Editorial
Adelaide Philibe, Advertising

•

Publications Committee
J. S. Schuchert, Chairman
J. R. Chambers
Brooks Chasseing
H. F. Davidson
R. W. Morris
R. M. Zabel

•

Executive Secretary
A. D. Hinckley

Technical Director
C. L. Crouch

Contents

189 Kitchen Lighting Integrated with Architecture — Melvin Cohen

192 Apparent Intensities of Colored Signal Lights — W. E. Knowles Middleton and Hanna S. T. Gottfried

197 I.E.S. Lighting Data Sheet — Series XXII
Floodlighting a Fountain (25-21)

199 Algebraic Interflectance Computations — J. R. Jones and John J. Neidhart

209 I.E.S. Lighting Data Sheet — Series XXII
Lighting a Motor Wiring Line (7-17)

211 Assessment of Brightness: What We See — R. G. Hopkinson

223 I.E.S. Home Lighting Data Sheet
Wall Lighting from Wall-To-Wall Fluorescent Bracket (22-56)

225 Multi-Functional Suspended Ceiling

226 Discomfort Glare at Low Adaptation Levels: II — Off-Axis Sources — Russell C. Putnam and Willard F. Gillmore, Jr.

233 I.E.S. Lighting Data Sheet — Series XXII
Lighting a Drafting Room (13-86)

235 Mercury Floodlighting — Its Advantages and Limitations — James R. Bale

8A Lighting News
Here and There with I.E.S. Members, 8A; About People, 16A; Books and Pamphlets, 50A; It Seems to Me, 51A; New Members, 51A.

21A Committee Personnel

30A I.E.S. National and Local Officers

48A I.E.S. National Technical Conference

58A Index to Advertisers

Sustaining Members — See March 1957 ILLUMINATING ENGINEERING.

STATEMENTS and opinions in articles and papers in ILLUMINATING ENGINEERING are the expressions of contributors and do not necessarily represent the policies or opinions of the Society. Official Society opinions are expressed only in official committee reports specifically approved by the Council of the Illuminating Engineering Society.

ILLUMINATING ENGINEERING SOCIETY

EDITORIAL and advertising offices
1860 Broadway, New York 23, N. Y.

PUBLICATION office 32d Street & Elm Avenue, Baltimore 11, Md.

Founded 1906

ILLUMINATING ENGINEERING: The Journal of the Illuminating Engineering Society. Copyright 1957 by the Illuminating Engineering Society. Published monthly in the United States of America. Entered as second-class matter at the Post Office, Baltimore, Md. Acceptance for mailing at special postage rates provided for in Section 1103 P.L.&R., Act of October 3, 1917. Authorized July 16, 1918. ¶ Subscription $12 per year plus extra postage to all countries to which second-class postage rates do not apply; single copies $1.00. ¶ Address changes must be received at I.E.S. headquarters by the first of the month to be effective with the issue of the next succeeding month.

ANNOUNCING WESTINGHOUSE FLUORESCENT LAMPS WITH

ULTRALUME®

HIGH INTENSITY PHOSPHORS

START BRIGHTER...
MAINTAIN BRIGHTNESS LONGER...

- **MORE LUMENS PER WATT**—more light for your dollar
- **PLUS UNIFORM END-TO-END LIGHT** . . always perfectly color-matched maximum light output maintained throughout life . . and carrying the **WESTINGHOUSE ASSURANCE** of performance satisfaction or full purchase price refund.
- Get the most for your lighting dollar—call your Westinghouse Lamp Distributor today, or write Westinghouse Lamp Division, Dept. I-4, Bloomfield, N. J.

YOU CAN BE SURE...IF IT'S

Westinghouse

ALL OFFICES NEED EYE-COMFORT...

CURTIS OFFICE LIGHTING SYSTEMS GIVE ASSURED EYE-COMFORT®...

Eye-Comfort is the result of planned lighting. Curtis Office Lighting Systems can assure Eye-Comfort because they provide the pleasant working environment and the high-level, quality illumination, properly distributed and free from glare that every office, big or little, needs for maximum employee efficiency and productivity.

Curtis Assured Eye-Comfort® Office Lighting Systems give you Assured Value per dollar spent too, because you get highest quality material and finishes, reliable components and economy of installation, operation and maintenance.

So for Assured Eye-Comfort® Office Lighting, plus Assured Value, call the nearest Curtis Sales Engineer or clip the coupon below, and get all the facts on a Curtis Assured Eye-Comfort® Office Lighting System.

CURTIS LIGHTING, INCORPORATED
6135 West 65th Street, Chicago 38, Illinois

CURTIS

in California:
242 S. Anderson St.
Los Angeles 33, California

•

in Canada
195 Wicksteed Ave.
Toronto 12, Canada

Curtis Lighting, Inc., Dept. A-2, 6135 W. 65th St. Chicago 38, Ill.
Send information on Curtis Assured Eye-Comfort® Office Lighting Systems

Name_____

Affiliation_____

Address_____

City_____ Zone_____ State_____

ABSOLUTELY NOTHING LIKE IT FOR FAST INSTALLATION AND FLEXIBILITY

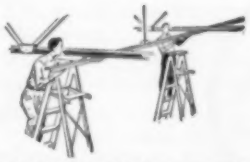
Snap—and It's Up. The inset shows how the plug built into the fixture automatically engages a receptacle in the Uni-Race. Simple hooks and latches fasten the fixture to the Uni-Race.

Contractors throughout the country report that a complete Gibson Ortho installation takes, on the average, only 22 man-minutes per fixture, including stems, lamping and mounting. That's just a fraction of the time required for conventional installations. But speedy installation is only part of the story. Consider the flexibility the owner enjoys. Ortho fixtures can be mounted in continuous rows or at intervals, and re-spaced at any time in a matter of minutes. Two-light fixtures can be replaced with four-light fixtures and vice versa. It's almost as easy as changing an incandescent bulb.

WRITE, WIRE OR CALL FOR COMPLETE INFORMATION

3 SIMPLE STEPS TO INSTALL THE ORTHO

1 Telescoping sections of Uni-Race assembled and wired on the floor.



2 Light but rigid Uni-Race assembly, up to 24', easily lifted and hung.

3 Fixtures snap into place in seconds without tools. No wired connection.

Patent Pending

Gibson LIGHTING

GIBSON Manufacturing Co.

1919 Piedmont Circle, N.E., Atlanta 9, Georgia

MAKERS OF THE NEW Ceilo•35 WORLD'S THINNEST FIXTURE WITH NO DARK AREAS

IN CANADA manufactured under franchise by Canada's oldest and largest manufacturer of lighting fixtures ELECTROLIER MFG. CO. Ltd., Montreal

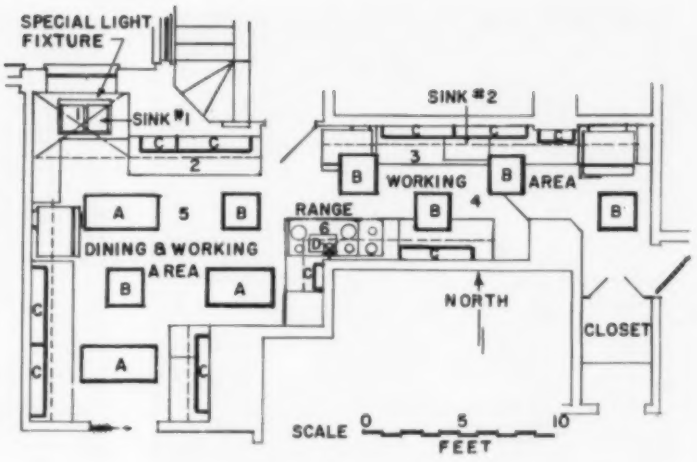
Figure 1. Plan of remodeled kitchen area.

Illumination — footcandles

Location	Low Level	High Level
1	45	57
2	70	80
3	—	110
4	—	35
5	38	65
6	—	40

Lighting Fixtures

Symbol	Type
A	Troffer — 2 x 4-foot, 4 40-watt
B	Troffer — 2 x 2-foot, 4 20-watt
C	Undercabinet light — 18-inch, 15-watt, 2-foot 20-watt, 4-foot 40-watt
D	Vaportight — 100-watt



Kitchen Lighting Integrated With Architectural Design

By MELVIN COHEN

ARCHITECTS more than ever realize the important part well planned illumination can play in the final evaluation of an architectural design. For the lighting design to complement the architectural design, it is essential that the illuminating engineer work harmoniously with the architect. This is especially true of remodeling work where the problems encountered are even more complex because of existing structural and electrical limitations.

How lighting can be successfully integrated with architectural design is exemplified in this remodeled kitchen. It is in the home of an executive of a large architectural and engineering firm. From the very beginning of the architectural plans, the illuminating engineer was orientated as to the owner's wishes, and to the design problems which would result.

These problems were: First, a new acoustical metal pan ceiling was placed on the underside of the existing plaster ceiling at a height of nine feet from the floor. The existing plaster ceiling was suspended from a concrete slab. The recessing distance between the new metal pan ceiling and the concrete slab is eleven inches except where concrete beams run north and south on approximately four-foot centers. At this point, the depth is only three inches between the underside of the beam and the new ceiling.

Second, because of the irregular shape of the remodeled kitchen, which was a combination of the old kitchen, butler's pantry and pantry closet, it was the owner's desire to have the lighting ceiling pattern tend to minimize the long corridor illusion of the east portion of the kitchen (working area) and to unite both the east and west portions.

Third, since the west portion of the kitchen was to serve as a dining area in addition to a working area, it was the owner's desire to provide two levels of illumination in this area.

Fourth, it was desired that there should be supplementary lighting over all working areas including sink No. 1 adjacent to the only window in the kitchen. However, an air-conditioning unit was to be placed above this sink; and it was necessary for all parts of this unit to be readily accessible for maintenance. Thus, it was not possible to place any permanent fixture on the underside of the unit.

Fifth, the owner's decorating scheme was contrary to accepted standards for a low brightness, efficient lighting installation. The ceiling is acoustical metal pan painted light blue (reflectance factor of 40 per cent); the cabinets are a wood grain laminated plastic (reflectance factor of 30 per

AUTHOR: A. Epstein and Sons, Inc., Chicago, Ill. Article submitted through the Papers Committee, Chicago Section, I.E.S.

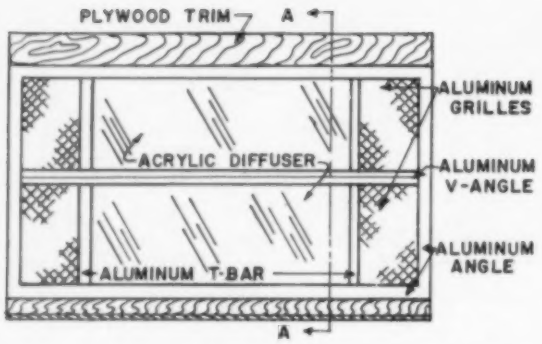


Figure 2A. Reflected ceiling plan of special lighting fixture over sink #1.

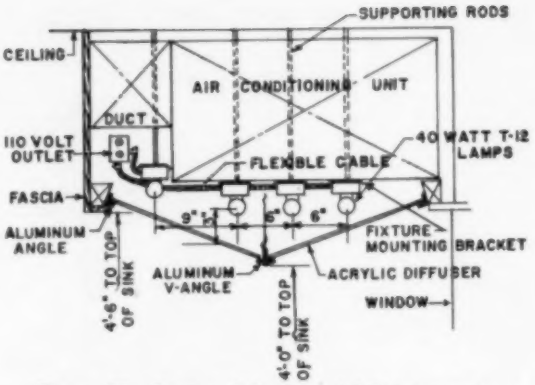


Figure 2B. Section A-A of special lighting unit.

cent); the walls below the cabinets are white ceramic tile (reflectance factor of 70 per cent); the counter tops are white laminated plastic (reflectance factor of 70 per cent) and wood block (reflectance factor 25 per cent); the floor is yellow asphalt tile (reflectance factor of 50 per cent).

With these limitations in mind, the first problem was the selection of a luminaire for general illumination. An eleven-inch-deep dropped acrylic plastic bottom troffer was eventually chosen. The type "A" fixture (refer to Fig. 1) is a four-foot by two-foot fixture with four 40-watt rapid start lamps, and the type "B" fixture is a two-foot by two-foot fixture with four 20-watt lamps with trigger start ballasts.

This choice of luminaire type serves a five-fold purpose. First, the dropped acrylic plastic diffuser enables more light to reach the ceiling, and thus decrease the brightness contrast between the luminaire and pale blue ceiling. Second, for a low reflectance ceiling and relatively high reflectance floor, direct lighting is more efficient than indirect or semi-direct. Third, the deep fixture depth serves to decrease the overall brightness of the luminaire. Fourth, by switching the lamps in the fixtures in the west portion of the kitchen (dining and working areas) alternately so that two or four lamps could be turned on; two levels of illumination are obtained. In addition, because of the eleven-inch depth of the luminaire, it is not possible to determine whether two or four lamps of each fixture are on.

The special unit over sink No. 1 at the window (refer to Figs. 2A and 2B) was designed to be dis-

Figure 3. (below) Before remodeling, same view as Fig. 5.

Figure 4. (right) Before remodeling, same view as Fig. 6.

Figure 5. Northwest corner of kitchen. Brightness readings with two levels of illumination.

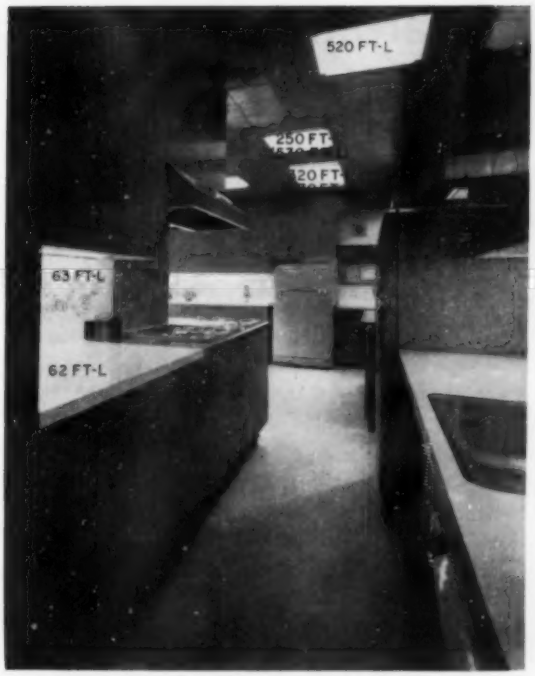


Figure 6. West wall of kitchen. Brightness readings with two levels of illumination.

assembled and assembled again easily without any tools, so that all parts of the air conditioning unit are readily accessible. In order to maintain the fascia height, which is the same throughout the kitchen, and still have adequate room for fluorescent channels under the air-conditioning unit, a V-shaped design was decided upon.

The fluorescent channels are snapped into fixture mounting brackets which are suspended by steel rods, fastened to the concrete ceiling above the air-conditioning unit. The fluorescent channels are wired with flexible cable and connected to a 110-volt receptacle which is out of sight on the wall above the lamps. The fixture has an acrylic plastic diffuser supported on aluminum angles. At each end of the plastic diffuser is an aluminum grill which allowed for proper air circulation for the air-conditioning unit.

To service the air-conditioning unit, it is necessary merely to tilt out the plastic shields and aluminum grilles, disconnect the fluorescent lights from their 110-volt source, and finally snap out the fluorescent channels from the mounting brackets.

To increase the illumination at the counter tops, supplementary lighting is added by means of triangular shaped under-cabinet fluorescent brackets (Fig. 1 — type "C" fixture) with Alba-Lite glass diffuser. In addition a 100-watt incandescent vapor tight bracket (Fig. 1 — type "D" fixture) was added under the hood by the range.

To further integrate the electrical design with the architectural design and thus enhance the appearance of the kitchen, 110-volt receptacles are placed on 18-inch centers in a metal raceway which was installed between the backsplash above the counter tops and the wall tile. The raceway, which is painted white to watch the wall tile, also houses the switches for the supplementary lights.

Illumination readings at various locations in the kitchen, taken one year after the installation, can be found in Fig. 1. The "low level" footcandle readings are taken with two lamps in each ceiling fixture in the dining and working area turned on; "high level" footcandle readings are taken with all four lamps in each ceiling fixture in the dining and working area.

Brightness readings are shown in Figs. 5 and 6. The footlambert values in parenthesis are taken with all four lamps illuminated whereas the other footlambert readings are taken with only two lamps in the ceiling fixtures in the dining and working area illuminated.

The success of the installation can be credited to a great extent to the complete cooperation between architect and engineer throughout the planning of the kitchen. Only by this harmonious alliance could the lighting design have been integrated with the architectural design for such optimum results.

Apparent Intensities of Colored Signal Lights

By W. E. KNOWLES MIDDLETON
HANNA S. T. GOTTFRIED

It has long been assumed that the luminous intensity I of a signal light of any color can be computed from a knowledge of its spectral radiant intensity J_λ by the equation

$$I = K_{max} \int_{0.38\mu}^{0.76\mu} J_\lambda \bar{y}_\lambda d\lambda \qquad (1)$$

in which K_{max} is the maximum luminosity of radiation (680 lumens per watt at $\lambda = 0.555$) and $\bar{y}_\lambda$ the C.I.E. 1931 photopic luminosity function. Indeed it has become the practice to *define* the intensity of a signal light by means of equation (1), without much consideration of the question whether signal lights of different colors, and having equal intensities calculated in this way, will in fact appear equally intense. Similar questions concerning the apparent brightness of surface colors have been dealt with in a review paper by Dressler,[1] and this suggested to us the desirability of finding out by direct experiment whether the relative *apparent* intensity of colored signal lights can actually be calculated by means of equation (1).

If, (as we discovered) this cannot be done for all colors, either or both the following causes may be operating: (a) the additivity law (Abney's law) implicit in equation (1) may not hold; (b) the luminosity function for point sources may differ markedly from the C.I.E. photopic luminosity function $\bar{y}_\lambda$. The present experiments afford no basis for distinguishing between these two causes, and are to be considered simply as a preliminary report of some engineering value. Further experiments of more theoretical importance are being carried out as part of a long range plan to investigate the perception of point sources.

Plan of the Experiments

The present experiments involved the comparison of pairs of point sources, one of which is always white (C.I.E. source "A") and the other colored. the method of constant stimuli was adopted, the white signal being held constant while the colored one could be given at random one of five known intensities. The two signals, each of which subtended about 0.5 minute of arc, were seen in a vertical line at an angular distance of 10 minutes. The colored signal could be either the lower or the upper one. Free binocular vision was allowed. The pair of signals was exposed for six seconds in each 10-second period until 20 observations had been made; then there was an intermission of 50 seconds, then 20 more observations, and so on until 80 observations had been accumulated, when a longer break was announced. The observers, who had first been dark adapted for five minutes, were instructed to indicate whether the upper or the lower signal appeared brighter. The judgment "equal" was not allowed.

For each group of 80 observations, the percentage of responses "colored signal brighter" at each of the five signal intensities was plotted against the intensity on normal probability paper. A best-fitting straight line was drawn by eye, and the median intensity corresponding to 50 per cent responses "colored signal brighter," was read off. Any run showing three or more 100 per cent or 0 per cent responses was discarded.

This process was repeated for 17 colors, distributed fairly well over the C.I.E. chromaticity diagram. The intensity of the various colored sources was adjusted so as to keep the calculated intensity of the matching white source approximately 20 times the foveal threshold.

In order that there could be no question about the spectral composition of the light from the point sources, a completely non-selective method of attenuation (rotating sectors) was used to obtain the five known intensities.

It should be noted that the intensity could not be kept precisely constant because of (a) the limited number of neutral filters available, and (b) the low transmittance of some of the most saturated filters.

Choice of Observers

To forestall criticism, very great care was taken to choose observers with normal color-vision. All were required to pass the Hardy-Rand-Rittler pseudo-isochromatic test, the New London Lantern

Authors: Division of Applied Physics, National Research Council of Canada, Ottawa, Ontario.

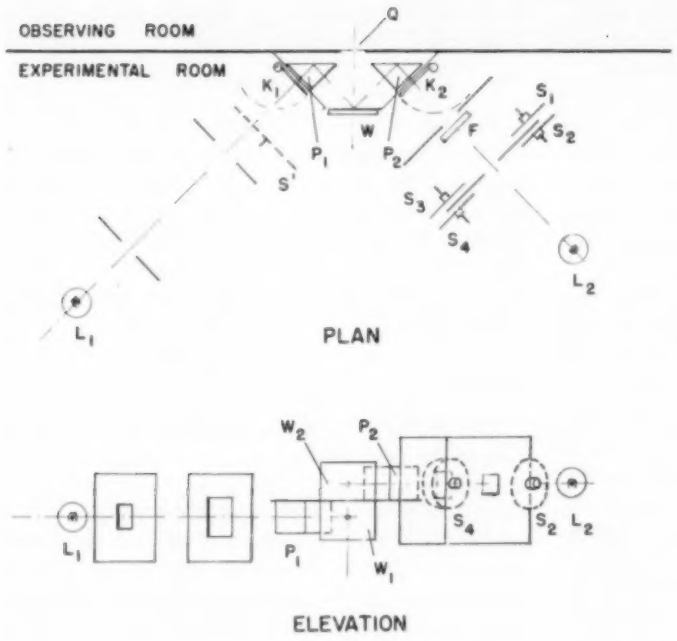


Figure 1. Schematic diagram of apparatus (see text). The adjustable sector indicated at S_1 was actually never used.

test, and the Farnsworth D-15 test. Those who passed all these tests without an error were further tested on a Nagel anomoloscope (New Schmidt and Haensch model). This instrument had been calibrated by testing about 160 persons, in order to arrive at central match and mixture readings. No observer was used whose combination reduced mid-point[2] had an absolute value greater than three for either eye, except for three observers who had a very low mid-point for one eye and a mid-point of four or five for the other. The maximum combination score[2] for any observer was 11.

It was administratively impossible to have all the observations made by the same set of observers, but a complete set (all the 17 colors) was made by two observers from the scientific staff of the National Research Council. Observations on several colors were made by a number of other observers, sufficient at least to show the generality of the phenomenon.

Instrumentation

The point sources of light were produced by means of the apparatus shown diagrammatically in Fig. 1. The white surfaces W_1 and W_2 were illuminated by the projection lamps L_1 and L_2 through the prisms P_1 and P_2. The colored signals were produced from L_2 by the use of appropriate filters at F, and any one (or none) of the four sectors S_1 to S_4 could be introduced into the beam from L_2 to produce one of five colored stimuli in a geometric series of intensities. The common ratio 0.9 was found suitable for this series. To prevent acoustic cues, a fifth dummy sector (not shown) was provided.

The attenuation of the colored signal by means of sectors ensured that their chromaticity did not vary with their intensity. The interruption of the light seems to have had no other effect on the phenomenon, since the points for the highest of the five intensities, which was not attenuated by a sector, always plotted as well as any of the others on the frequency curves which were made from the observations.

The sectors were driven by individual miniature motors of the type used in model railroad locomotives. This scheme, however, cannot be recommended. These motors, evidently not being designed for such continuous service, gave much trouble.

In order to keep the calculated intensity of the various colors roughly the same, neutral (Wratten) filters of suitable densities were added at F; or in the case of some of the darker colors a lens system was used in front of L_2 in order to increase the available energy. Where a neutral filter was used at F, a similar one was placed in front of L_1.

The white signal produced by L_1 was adjusted by the use of the inverse-square law. Both signals were simultaneously exposed by solenoid operated shutters K_1 and K_2.

Most of the observations were made with the colored signal above the white one, as indicated in

Fig. 1; but it was possible to rearrange the apparatus so that the colored signal was the lower one, and some observations were made in this manner.

The observers sat in the observing room at a distance of 7 meters from the two holes Q through which the illuminated surfaces were visible. Each observer was provided with a two-position momentary contact key with which he could indicate whether the upper or the lower signal appeared the brighter.

A fairly elaborate circuit was constructed for the automatic presentation of the stimuli and the counting of the responses. This will not be described, as it differs in no essential principle from other such apparatus[3] though the mechanical and electrical arrangements were original. It will be sufficient to say that the responses of each of two observers to the five randomly-presented stimuli were recorded on 10 electrically operated counters, with an additional counter as a totalizer. A buzzer sounded about half a second before the opening of the shutters. Verbal instructions could be given over a microphone and loud-speaker system.

Whenever two subjects observed together, they changed places at the end of each group of 80 observations.

Photometry

The seventeen filters used were spectrophotometered and the chromaticity co-ordinates x, y, and transmittance Y calculated by the usual methods, on the basis of the 1931 C.I.E. standard (photopic) observer and co-ordinate system.

In order to be able to compute the relative intensities of the white and colored signals from the results, it was necessary to know the distance between the lamp L_1 and the screen W_1 which would make the two signals equally intense when the colored filter was removed from the position F. After trying simpler methods, it was finally decided to use a photoelectric telephotometer with its entrance pupil placed approximately where the eye of the observer would be during the experiment. Arrangements were made to operate the shutters K_1 and K_2 separately so that the two white signals could be directly compared. This method had the further advantage that separate measurements could be made from the positions occupied by each of the two observers. The precision of the combined operation of photometry and setting L_1 was about $\pm$ 3 per cent.

The absolute intensity of the white signal was measured by removing the small brass plate in which the holes Q were drilled and measuring the luminance B (cd.m^{-2}) of the screen W_1 with a MacBeth illuminometer. If the area of one of the holes is Sm^2 the intensity is then

$$I = SB \text{ candelas}$$

This was in the vicinity of 2.5×10^{-5} candelas for the main experiment, giving an illuminance at the observers' eyes of 5×10^{-7} lm.m^{-2}, which is about 20 times the foveal threshold for a dark background.[4] For the reasons stated in the section on Plan of Experiments, this illuminance varies by a factor of about two in each direction between different colors.

Results

The results to be presented below all refer to a completely dark background, to a subtense of 0.5 minutes of arc, to a distance of 10 minutes of arc between signals, and to signals matching a white signal which is in the vicinity of 20 times the foveal threshold. This is, of course, only one of a large number of possible combinations, but the necessary observations and computations for this one set of conditions consumed a great deal of time, and it is hoped that at least a general outline of the phenomenon has been obtained.

The numerical results may well be prefaced by a few words on the subjective impressions of the observers. As is generally the case in forced-choice experiments, the observers felt little confidence in the significance or consistency of their reports; yet, in most instances they proved to be highly reliable. Some colors were felt to be much more "difficult" than others, and this was sometimes, though not always, reflected in the scatter of plotted points. More interesting is the feeling of one observer that the colored signals looked brighter for the first fraction of a second than later in the 6-second exposure. Another observer felt that some colors started by being faint and increased to a maximum. The observers were actually encouraged to wait until the end of the presentation before signalling their response, and the circuits were arranged (at the cost of some complication) so that the first decision signalled could not be changed. The feeling of temporal alteration in the signals may be connected with the phenomena discussed by Boynton.[5]

The results are summarized in Tables I and II. Table I refers to the two observers who were able to make obervations on all the seventeen colors; Table II to the miscellaneous observations of a number of others. In the first five columns of Table I, the designation of the filter is given (Cg = Corning, W = Wratten), its color name,[6] and its chromaticity co-ordinates and integral transmittance for C.I.E. source "A."

TABLE I — Results for Two Observers on Seventeen Colors

Filter	Color Name	Y	x	y	Signal Intensity(1)	Observer R.B. R	±	N	j.n.d.	Observer G.W. R	±	N	j.n.d.
Cg 2412	Red	.134	.707	.293	39 x E_t	2.40	± 0.39#	3	.056	1.52	± 0.04#	3	.074
W. 30	Red	.412	.595	.331	25	1.30	± 0.09	3	.047	1.18	± 0.13	3	.064
Cg 3484	Orange	.691	.562	.436	21	1.09	± 0.04	3	.061	0.97*	± 0.09	3	.070
W. 17	Yellowish Orange	.897	.490	.458	23	1.12	± 0.04	3	.038	1.12	± 0.09	3	.082
W. 11	Yellow Green	.373	.383	.544	23	1.00*	± 0.04	3	.057	1.11	± 0.09	3	.080
W. 58	Yellowish Green	.202	.272	.679	17	0.89	± 0.04	3	.059	0.89	± 0.04	3	.072
W. 74	Yellowish Green	.0385	.240	.731	44	1.16	± 0.09	3	.041	1.11*	± 0.13	2	.082
W. 63	Green	.0326	.117	.680	19	0.89*	± 0.13	2	.060	0.83*	± 0.25	2	.054
W. 64	Green	.176	.175	.542	15	0.96*	± 0.04	3	.065	0.88	± 0.04	3	.081
W. 75	Blue Green	.0074	.066	.349	10	0.84	± 0.09	3	.094	0.83	± 0.04	3	.090
W. 38A	Blue Green	.109	.181	.310	23	0.99*	± 0.13	3	.054	0.94*	± 0.25	2	.060
W. 46	Blue	.0083	.128	.087	10	0.81	± 0.04	3	.061	0.82	± 0.09	3	.068
Cg 5543	Purplish Blue	.0145	.146	.067	13	0.57	± 0.04	3	.059	0.57	± 0.04	3	.068
W. 34	Reddish purple	.0163	.296	.086	35	1.42	± 0.10	6	.049	1.30	± 0.08	5	.054
W. 34A	Red Purple	.0356	.388	.128	24	1.40	± 0.09	4	.061	1.28	± 0.06	4	0.67
W. 32	Purplish red	.182	.552	.236	40	2.39	± 0.52	3	.062	1.49	± 0.09	3	.048
Cg 5900	Bluish White	.156	.316	.327	20	1.16	± 0.09	3	.055	1.03*	± 0.04	3	.088

#These deviations represent the 95% confidence limits.
*For these colors, R is not different from unity at the stated confidence level.
(1) Intensity of white signal required to match colored signal, expressed in terms of E_t, the foveal threshold for white light.

In the sixth column is given the intensity of the white signal required to match the colored signal, in terms of a signal which would produce an illuminance equal to the foveal threshold for white light, taken as 2.5×10^{-8} lumens m^{-2}.

The ratio R of the observed apparent intensity of the colored signal to the intensity calculated by means of equation (1) is given in the seventh column, together with 95 per cent confidence limits computed from the dispersion of the results of N groups of 80 presentations (column 8). Finally the just noticeable difference (j.n.d.) is given, computed from the slopes of the lines on probability paper which represent the frequency-of-response functions for the groups.

Table II is presented only to show that the phenomenon under study is not peculiar to the observers R.B. and G.W. Not much need be said about this table except that the differences between observers represent the sort of personal effect experienced in all heterochromatic photometry, exaggerated here because of the difficulty of the task.

Referring again to Table I, it will be seen that for most of the filters the 95 per cent confidence limits do not include the value 1.00, so that it is highly probable that the apparent intensity of these signals cannot be calculated by equation (1). The discrepancy is especially striking in the red and in the blue, the red signals being much more intense, and the blue ones much less so than calculated.

Observations by three observers on five colors show no certain dependence on whether the white or the colored signal was uppermost.

No claim whatsoever is made for the universality of these figures. It is fairly certain that the chro-

TABLE II — Results for Additional Observers

Observer	Filters Cg.2412 R	N	W.30 R	N	Cg.3484 R	N	W.11 R	N	W.58 R	N	W.64 R	N	Cg.5900 R	N
E.C.	1.72	6	1.58	5	0.95	5	0.99	2	0.75	1	0.81	4	1.08	4
R.K.	2.13	12	1.55	5	1.03	4	1.13	4	1.15	5	0.98	4	1.07	5
P.P.	2.05	9	—		0.87	5	0.96	4	0.96	4	0.81	4	0.95	4
G.S.	2.06	12	1.40	3	0.99	5	1.16	4	1.18	4	1.03	4	1.02	5
D.S.	2.05	9	—		0.93	5	1.02	2	1.13	3	0.89	5	0.98	4
A.B.	2.14	4	1.68	1	0.99	1	1.13	1	1.33	1	—		—	
B.C.	2.38	4	1.52	1	1.00	1	—		1.42	1	1.21	1	1.25	1
A.M.	2.04	2	—		0.90	1	—		—		1.16	1	1.26	1
A.L.	2.07	2	1.45	2	0.90	1	1.07	1	1.17	1	0.91	1	0.95	1
D.P.	2.18	4	1.57	1	1.03	1	1.18	1	1.31	1	1.11	1	1.28	1
W.S.	1.96	4	1.34	1	0.86	1	—		—		1.23	1	1.23	1
D.M.S.	1.90	2	1.47	2	0.86	1	1.03	1	0.94	1	0.79	1	0.86	1
L.T.	2.14	3	1.36	1	0.91	1	—		1.14	1	1.07	1	1.08	1
R.A.	1.62	4	1.35	4	0.99	5	0.80	3	—		0.71	5	—	
R.H.	1.85	5	1.48	5	1.19	4	0.93	4	—		0.99	4	—	
R.B.	2.40	3	1.30	3	1.09	3	1.00	3	0.89	3	0.96	3	1.16	3
G.W.	1.52	3	1.18	3	0.97	3	1.11	3	0.89	3	0.88	3	1.03	3
Weighted mean	2.02		1.44		0.98		1.00		1.07		0.92		1.06	
N	89		37		47		38		29		43		35	
σ*	0.20		0.12		0.09		0.13		0.16		0.13		0.10	

*σ is that of the distribution, not of the mean.

TABLE III — Comparison of Results With High and Low Intensity

Filter	Observer R.B.				Observer C.W.			
	Low Intensity		High Intensity		Low Intensity		High Intensity	
	R	N	R	N	R	N	R	N
Cg. 2412	2.40 ± 0.39	3	1.65 ± 0.30	3	1.52 ± 0.04	3	1.71 ± 0.52	3
Cg. 3484	1.09 ± 0.04	3	1.24 ± 0.13	3	0.97 ± 0.09	3	1.28 ± 0.26	3
W. 58	0.89 ± 0.04	3	1.39 ± 0.26	3	0.89 ± 0.04	3	1.36 ± 0.30	3
W. 64	0.96 ± 0.04	3	1.29 ± 0.26	3	0.88 ± 0.04	3	1.24 ± 0.30	3

matic aberration of the eye plays a large role in such observations, and this aberration varies a great deal between observers.[7] Thus the amount of blurring of the extreme colors is different for different people. Because of this, it is not considered useful to draw any theoretical conclusions from these observations.

Neither is it certain whether the departures from calculated intensities are due to a change in the luminosity function, or to the failure of Abney's law, or both. It may perhaps not be entirely superfluous to mention that the use of the C.I.E. *scotopic* luminosity function equation (1) leads to very much worse correspondence with the observations.

The phenomenon is probably somewhat sensitive to the actual intensity level of the signals. Two observers made observations on four of the filters at approximately eleven times the intensity employed in the main experiment. Table III shows the results of these observations, with 95 per cent confidence limits. It would seem that there is just about one chance in 20 that this variation of intensity has no effect.

Conclusion

It is believed that the experiments described in this paper furnish a negative result to the question whether it is safe to compute the intensity of a colored signal light by means of equation (1). This procedure, for red and blue light, appears to be very much in error, at least if we assume that it is valid for white light. There seems to be little possibility of arriving at a theoretical interpretation of these results without measuring the color-mixture functions, and it seems to us that it is impracticable to do this at all without correcting the chromatic aberration of the eye. This appears to be one of those rare situations in which an increase in scientific precision is inevitably accompanied by a decrease in practical utility.

It seems fortunate that the distant red signal always appears more intense than computations of the usual sort would suggest.

The authors wish to express their extreme gratitude to their colleagues Dr. R. E. Bedford and Dr. G. W. Wyszecki for their patience in acting as observers and for valuable suggestions.

References

1. Dressler, A.: *Trans. Illuminating Engineering Society* (London), Vol. 18, 141 (1953).
2. Willis, Marion P., and Farnsworth, Dean: "Comparative Evaluation of Anomaloscopes," U. S. Naval Submarine Base, Med. Res. Lab. Rep. No. 190, August 18, 1952.
3. For example see Blackwell, H. R., Pritchard, B. S., and Ohmart, J. G.: *J. Optical Society of America*, Vol. 44, 322 (1954).
4. Blackwell, H. R.: *J. Optical Society of America*, Vol. 36, 624 (1946).
5. Boynton, R. M.: *J. Optical Society of America*, Vol. 46, 172 (1956).
6. Kelly, K. L.: *J. Optical Society of America*, Vol. 33, 627 (1943).
7. Wald, G., and Griffin, D. R.: *J. Optical Society of America*, Vol. 37, 321 (1947).

I.E.S. Officers and Committee Personnel

Listings of the I.E.S. National and Local Officers and of the Committee Personnel — Standing, General, Task and Technical — begin on pages 30A and 21A, respectively, this issue.

INSTALLATION AT ALOE PLAZA OPPOSITE UNION STATION, ST. LOUIS, MO.

Floodlighting a Fountain

LIGHTING OBJECTIVE: To floodlight a fountain increasing its effectiveness and beauty for the many people who pass it at night.

GENERAL INFORMATION: The theme of the fountain is the meeting of the Missouri and Mississippi rivers just north of St. Louis and it is appropriately named "The Meeting of the Waters." The bronze statues, all designed and cast by the Swedish sculptor Carl Milles, are positioned in two groups — one led by a male figure representing the Mississippi river and the other led by a female figure representing the Missouri river.* The figures are bronze with verdi-antique patina which has weathered a near black-green, and the water basin walls are a very dark green granite. The sprays of water are in the shape of parabolas directed so that most of them go over the shoulders of the figures and the arches dovetail into each other.

When the fountain was dedicated in 1940 Mr. Milles did not want to have it floodlighted, but years later agreed that lighting the streams of water and the bronze statues would increase their beauty and effectiveness. Various floodlighting plans were suggested; the final solution took

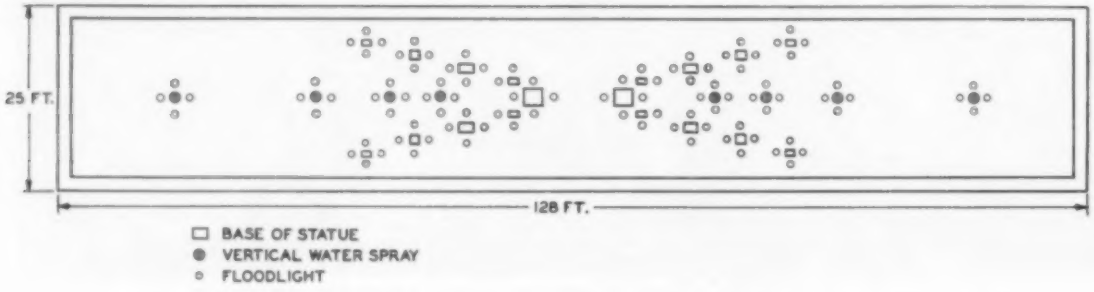
*The accompanying water creatures are symbols of the many streams which contribute their riches to the major currents, the sculptures are embodiments of the freedom and primal force of the waterways of the Mississippi Valley in accordance with man's age-old impulse to represent the power of nature in human or animal form. "The Meeting of the Waters" is conceived as a festival in which all these water forces are taking part.

(over)

A.I.A. File No. 31-f

Figure 2. (left) Photograph with water sprays turned off, showing floodlight locations.

Figure 3. (below) Plan view showing locations of floodlights, statues and vertical sprays.



into account the artistic creation and viewing angles, keeping the center of interest on the two main figures. The fountain lights were dedicated on October 19, 1954, during Light's Diamond Jubilee celebration.

INSTALLATION: A total of 96 Westinghouse WF 8 Style No. 1372675 underwater floodlights are mounted below the statuary and water sprays as shown in Figs. 2 and 3. The floodlight beams are directed at the statuary at approximately 10 degrees from the vertical. About half the units use 400-watt G-30 lamps, and the others 250-watt P-25 (or G-30) lamps. The resultant brightness pattern is as follows (daytime readings with overcast sky also shown for comparison):

	Daylight	Floodlighted
Surface of dark bronze central figure (mermaid's back)	180 ft-L	2.2 ft-L
Surface of turbulent water (night readings taken over upturned lenses of floodlights from position very close to basin wall)	1800-2100 ft-L	400 to 1800 ft-L
Water spray	2500-3500 ft-L	8 to 46 ft-L

Lighting designed by Carter Lewis and Wm. Simms, Union Electric Co., St. Louis; installed by Fremder Electric Co., St. Louis, Mo.

Lighting data submitted by Carter Lewis as one solution to a lighting problem and to aid in the design of similar installations.

Published by the Committee on Publications of the Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.

Series XXII 4-57

Algebraic Interflectance Computations

By J. R. JONES
JOHN J. NEIDHART

In the period from 1916 to 1920 Harrison and Anderson[1] attacked the problem of developing a method by which illumination levels produced in rooms by lighting systems might be predicted through calculations. In the development of their method they made measurements of illumination produced by different luminaire types in a wide variety of room shapes having varying reflectances. They recognized that room shape materially affected illumination at the working level and established a method of classifying rooms according to shape by a room ratio. The same room ratio formula for square rooms continues in use today. A modification of the rectangular room formula was discovered in 1928 by Margoulis[2] and was accepted after Crouch and Freyer[3] demonstrated its effectiveness using Harrison and Anderson's measured data.

The method of predicting illumination developed by Harrison and Anderson was an empirical one which fit the conditions and luminaire distributions tested very well; but it proved inadequate for the wide variety of conditions encountered later, so a different treatment was needed. A mathematical method offers advantages over empirical methods in that luminaire zonal flux may be properly evaluated and weighted. And mathematical systems are more flexible and versatile in that luminaire types and distributions as yet unconceived may be treated with a high degree of accuracy. Therefore an accurate mathematical system has been sought for many years.

Though much mathematical background was provided by Yamauti and Buckley, Moon and Spencer first generalized the material, broadened its scope, and published data to make such a mathematical system available to the industry.[4] They published tables of the fraction of lumens striking or emanating from each of the room surfaces that ultimately reach the working area. The fractions were given the symbols f_1, f_2, and f_3 and were called wall interflectance, ceiling interflectance, and floor interflectance respectively. Interflectance tables were published for various combinations of room shape and room surface reflectances. A room ratio was used which for square rooms was equal to ceiling height over room width, h/w, and was given the symbol k_r. This room ratio, k_r, appears in all the interflectance formulas and is a fundamental factor in computing interflectance values. In the development of the Algebraic Method that follows later k_r was found useful.

Also based on the "integral equation theory," as was Moon and Spencer's, was another solution by Dourgnon.[5] Later work was done by Dourgnon and Cadiergues.[6] They did not find it necessary to use an approximation employed by Moon and Spencer, and have obtained different interflectance values. The values published by Dourgnon and Cadiergues are theoretically applicable only to rooms with zero reflectance work plane, though they report that Codegone has shown how a reflecting floor could be comprehended. The room ratio sometimes used in their system is, for a square room, equal to ceiling height above the work plane divided by room width (and is equal to k_r times 0.75, or technically, k_r times the ratio of ceiling height above the work plane to ceiling height) and will be referred to as "R" hereafter.

Algebraic Method

A third method of computing interflectance values has been developed by the writers. Since it is based on elementary algebra, it is called the Algebraic Method. The derivation of the formulas is given in the appendix.

The most logical method of attack on the problem of computing interflectances is to follow the flux through its successive reflections about the room, and add the fraction that passes through the work plane on each successive trip. These fractions become less and less so that after several are added one has comprehended *almost* all the light that reaches the work plane. But by the time sufficient accuracy is obtained one has a formula that is so long that solution is too laborious.

Those who have worked on the problem have

A paper presented at the National Technical Conference of the Illuminating Engineering Society, September 17-21, 1956, Boston, Mass. AUTHORS: Westinghouse Electric Corp., Los Angeles, Calif., and The Miller Co., Meriden, Conn., respectively.

noted that the formulas for the individual fractions form the individual terms of geometrical progressions, the sum of which is a simple formula. Some of these progressions are noted easily, others less easily. The desirable solution would, of course, be found if the sums of the progressions could themselves be arranged to form higher order progressions whose sums would again be simple formulas, and these sums again arranged into additional progressions, whose sums are simple, etc. Thus, ultimately the final sum would comprehend *all* the fractions of initial flux that *ever* pass through the work plane.

While simple in principle final success has been elusive because no one has been able to arrange all the progressions in just the proper manner to avoid ultimate confusion. However, because of a system of identifying flux paths, and a shortcut used to comprehend floor contributions, the authors have achieved a solution.

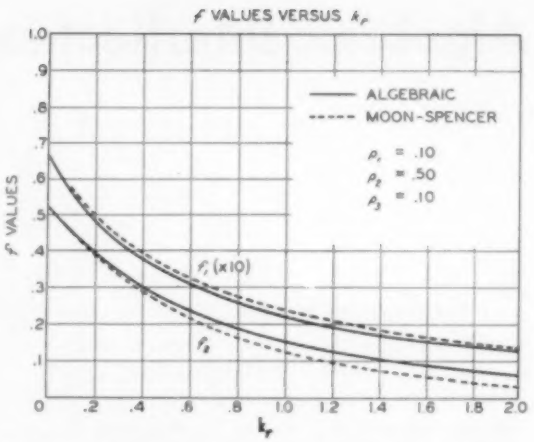


Figure 2. Interflectances computed by the Algebraic and Moon-Spencer Methods are plotted against room shape. Reflectances are: ceiling, 0.50; walls, 0.10; floor, 0.10. The f_1 values have been increased by a factor of 10.

Comparison of Interflectances

In Figs. 1 and 2 Algebraic and Moon and Spencer f_1 and f_2 values are plotted against k_r. In both instances the Algebraic Method yields slightly lower values for f_1 for nearly all room shapes, but higher values for f_2, particularly for the higher values of k_r. The effect of these variations is discussed under "Calculated vs Measured Data." The room surface reflectances in Fig. 1 were selected because they are quite representative of many interiors. The reflectances in Fig. 2 were selected to demonstrate the greatest percentage difference between f_2 values computed by the two methods. Values for f_3 are not plotted because the differences are similar to the differences in f_2.

In Fig. 3 the rooms have zero reflectance at and below the work plane. A comparison shows the Algebraic and Dourgnon-Cadiergues Methods yield results that are very close. Perhaps they would be identical if all mathematical errors were eliminated. It is regrettable that the latter values were not computed and published for varying room surface (including floor) reflectance combinations because they may have removed much of the variation between measured and calculated utilization factors. In order to achieve such a satisfying comparison

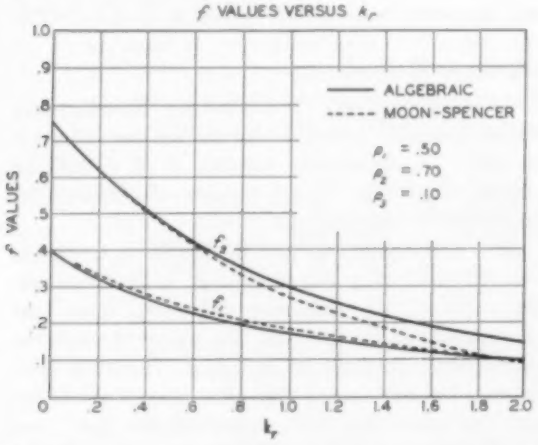


Figure 1. Interflectance values, f_1 and f_2, as calculated by the Algebraic and Moon-Spencer Methods are plotted against room shape, k_r. Reflectances are: ceiling, 0.70; walls, 0.50; floor, 0.10.

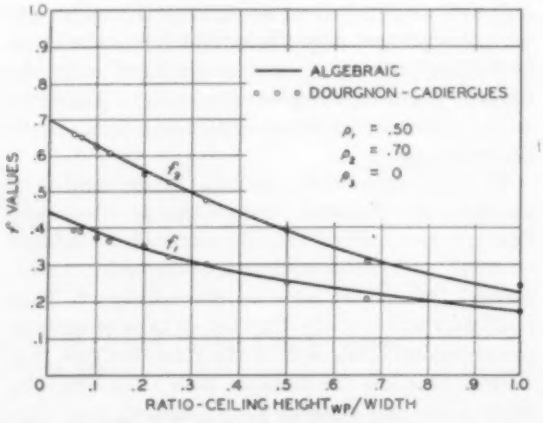


Figure 3. Interflectance values computed by the Algebraic and Dourgnon-Cadiergues Methods are plotted against room shape. Rooms are assumed square. All surfaces below the work plane are assumed black. Ceiling reflectance is 0.70, walls, 0.50.

TABLE I[9] — Measured and Calculated Utilization Factors — Silvered Bowl Indirect.

(Test units: three concentric rings, finished black inside. Calculations based on exact room conditions. Square room, width = 12.5 feet. Work plane height — 30". Reflectances: ceiling, 0.80; walls, 0.50; floor, 0.14)

Room Ratio	0.75	0.9	0.9	1.2	1.2	1.5
Number of Units	4	4	9	4	9	9
Spacing/susp. (S/su)	3.25	3.25	3.05	3.25	3.05	3.05
Ceiling Ratio	0.746	0.746	0.807	0.746	0.807	0.807
k_r	1.2	1.033	1.033	0.825	0.825	0.700
Measured U.F.	0.251	0.300	0.304	0.378	0.380	0.438
MOON-SPENCER VALUES						
f_1 (wall interfl.)**	0.1667	0.1867	0.1867	0.2152	0.2152	0.2340
f_2 (ceil. interfl.)**	0.2246	0.2841	0.2841	0.3810	0.3810	0.4543
Calculated U.F.	0.210	0.259	0.265	0.339	0.349	0.411
Diff. in per cent***	16.3	13.6	12.8	10.8	8.1	6.1
ALGEBRAIC VALUES						
f_1 (wall interfl.)**	0.159	0.179	0.179	0.2059	0.2059	0.225
f_2 (ceil. interfl.)**	0.270	0.321	0.321	0.403	0.403	0.468
Calculated U.F.	0.242	0.2855	0.2936	0.3528	0.3647	0.4215
Diff. in per cent***	3.6	4.8	3.4	6.7	4.0	3.75

*Fraction of output directly incident on ceiling. Based on special zonal multipliers for 5-degree zones and smaller, derived graphically as explained in Appendix (of Reference 9).
**Specially calculated "f" factors for surface reflectance and exact room dimensions.
***Difference between measured and calculated factors in per cent of the former.

the Algebraic Method was altered to yield floor illumination for rooms in which k_r is equal to the room ratio R of Dourgnon-Cadiergues.

Calculated vs Measured Data

Several studies have been made to check the accuracy of calculations utilizing the interflectance data of Moon and Spencer. Some of the tests found good agreement between measured and calculated values.[7] In other experimental works agreement was favorable, or less so, depending on the luminaire distributions and room conditions.[8] In general, it has appeared to the writers that the least accurate computations are those involving the ceiling reflectance, f_2, in high narrow rooms. This was clearly evident in measurements made by the authors and in tests by Potter and Russell using more flexible facilities.[8]

Since the greatest published differences were for totally indirect luminaires (or bare silvered bowl lamps) a comparison is made for this equipment. Since only Potter and Russell published precise ceiling ratios their data are used in Table I.[9] Further, their data are considered to have a very high degree of accuracy. The maximum error they showed was 16.3 per cent for indirect equipment and this particular error is reduced to 3.6 per cent using the Algebraic Method.

Differences still exist between measured and computed data but the smaller differences can be explained, largely at least, as being due to a non-uniformly bright ceiling. Potter and Russell mentioned this as a factor contributing to the higher measured values.

Test measurements have indicated calculations are much more accurate for other luminaire distributions. Therefore, only minor changes in computed results should be expected for other than the indirect, and to a lesser degree, semi-indirect classifications. This has been found to be the case. Since the Algebraic f_1 values are usually lower, and the f_2 values higher than the Moon-Spencer values, Algebraic computations will yield results that are about equal or only slightly higher for general diffuse classifications. Little change is found for semi-direct equipment, and for totally direct luminaires Algebraic predictions are slightly lower, the greatest difference being about three per cent.

Formulas and Their Use

The formulas are extremely elementary and require only simple algebra for their solution. The values of f_2 and f_3 are functions of f_1. The formulas follow:

$$f_1 = A + (Au + A\rho_2 uv + \rho_2 vt)\left(\frac{\rho_3}{1-\rho_2\rho_3 v^2}\right)\left(\frac{\rho_1 x + \rho_1\rho_2 xv}{1-\rho_1 y - \rho_1\rho_2 xu}\right)$$

where

$$A = \frac{\rho_1 z + \rho_1\rho_2 xt}{1-\rho_1 y - \rho_1\rho_2 xu}$$

$$f_2 = (t + f_1 u + f_1\rho_3 uv)\left(\frac{\rho_2}{1-\rho_2\rho_3 v^2}\right)$$

$$f_3 = \rho_3 (f_1 u + f_2 v)$$

where

f_1 = wall interflectance (per cent of initial flux striking the wall that ultimately reaches the work plane).

f_2 = ceiling interflectance

f_3 = floor interflectance
ρ_1 = wall reflectance
ρ_2 = ceiling reflectance
ρ_3 = floor reflectance

The sylbols t, u, v, x, y, and z represent the percentages of flux reflected from one room surface that strike directly another room surface or pass through the work plane. No inter-reflections are considered. All are expressed as a decimal. The particular room surfaces involved and the direction of travel of flux for each symbol are presented in Table II. Values for each symbol, plotted against room shape are given in Fig. 4.

Since this method, like others, assumes the walls, ceiling and floor to be perectly diffusing, it is possible to compute values for each of the symbols for each room shape. Except for t and z the values depend only on room shape. The values of these two depend also on the ratio of work plane height to ceiling height, assumed to be ¼ for the values shown in Fig. 4. Values for t and v were computed from published data,[10] and the values for the other symbols were computed for these two. Because of the principle of reciprocity the values of the symbols are related as follows:

$$u = 1.0 - v$$

$$y = 1.0 - 2x$$

$$x = u\left(\frac{\text{ceiling area}}{\text{wall area}}\right)$$

$$z = (1.0 - t)\left(\frac{\text{ceiling area}}{\text{wall area}}\right)$$

The formulas for f_1 and f_3 do not comprehend any flux that passes through the work plane enroute from the luminaires in the room to the lower walls and floor. This flux should be comprehended through the use of the Direct Ratio. The Direct Ratio and luminaire flux that initially strikes the walls, ceiling, and floor can be computed using Zonal Multipliers.[11]

TABLE II — Meanings of Symbols.

Symbol	From	To
t	ceiling	work plane
u	ceiling	walls
	or floor	walls
v	ceiling	floor
	or floor	ceiling
x	walls	ceiling
	or walls	floor
y	one wall	other three walls
z	walls	work plane

For example, t represents the fraction of flux reflected from the ceiling that strikes the work plane directly (with no further reflections). For values of the symbols plotted against room shape see Fig. 4.

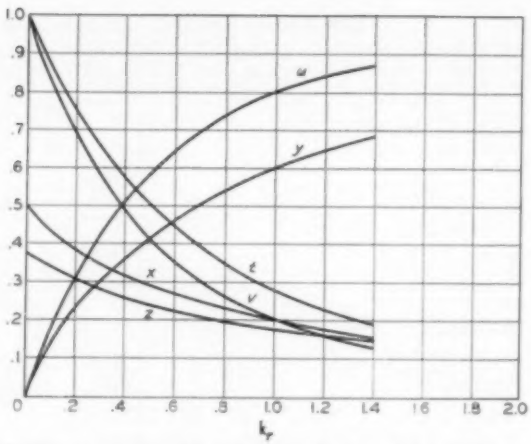


Figure 4. Curves show the fractions of light reflected from one room surface that strike another room surface for a range of room shapes. See Table II for the meaning of the letters. Values apply exactly only for square rooms, but are close approximations for rectangular rooms. k_r equals ceiling height over room width for a square room.

Assumptions

Certain assumptions must necessarily be made in any method for computing interflectance values. For this method the assumptions are:

(1) room surfaces are perfectly diffusing,

(2) the initial and final brightness of each room surface is uniform,

(3) the reflectance of each room surface is uniform,

(4) the color of all room surfaces is neutral.

These are basically the same assumptions employed by Moon and Spencer and by Dourgnon and Cadiergues except that the former do not assume final wall brightness is uniform (vertically), but they do assume a "Kernel" is equal to an exponential function. The assumptions are the same as those of Dourgnon and Cadiergues except that they do not state that the initial ceiling, wall, or floor brightnesses were assumed uniform.

The authors appreciate the help of F. B. Carter, P. Presbrey, and R. L. Zahour in preparing the drawings.

Appendix

There are several possible methods of computing interflectance, but the most logical is to follow the flux through its successive reflections from one room surface to another. This was the system used in deriving the interflectance formulas of this Algebraic Method. To illustrate the technique used, let us compute the per cent of the flux directed to the walls that actually reaches the work plane in a room having a black ceiling and black floor.

Initially, the flux is assumed to be directed to the left wall (having a reflectance of ρ_1). Part of it ($\rho_1 z$) is

reflected to the work plane, part to the ceiling where it is absorbed, and part $(\rho_1 y)$ of the original flux is reflected to the other walls and is then re-reflected in the same manner as the original flux.

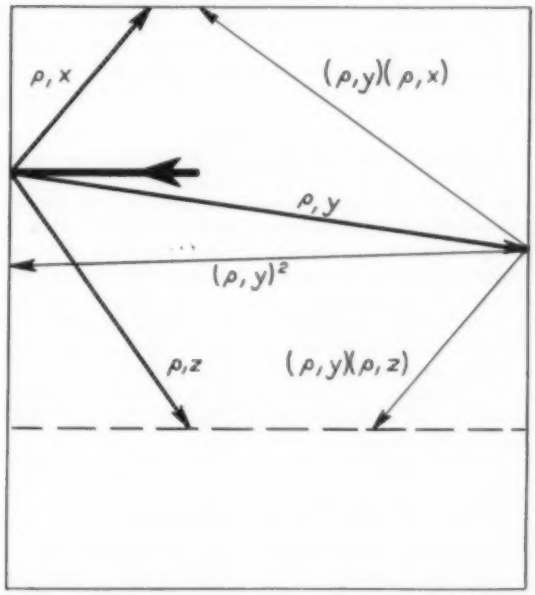


Figure A-1. Flux is assumed directed to the left wall. Part, $\rho_1 x$ is reflected to the ceiling; part, $\rho_1 z$ is reflected to the work plane, and part, $\rho_1 y$ is reflected to the other three walls. Of the part reflected to the other three walls, part is rereflected to the ceiling, part to the work plane, and part to the other three walls. For the meanings of the letters see Table II. Values of the symbols are given in Fig. 4.

Thus,

$$f_1 = \rho_1 z + (\rho_1 z)(\rho_1 y) + (\rho_1 z)(\rho_1 y)^2 + (\rho_1 z)(\rho_1 y)^3 + (\rho_1 z)(\rho_1 y)^4 + \ldots$$

$$= \frac{\rho_1 z}{1-\rho_1 y}$$

However, it is much easier to write the formulas and to follow the flux through its successive reflections if travel of flux from wall to work plane is abbreviated $W(WP)$, and the travel from wall to wall to work plane is abbreviated $WW(WP)$, etc. (if flux were travelling from wall to ceiling to wall to work plane it would be abbreviated $WCW(WP)$). Thus, in writing the formulas it is necessary only to count the W's to determine the power (exponent) of ρ_1, and to count the number of C's to determine the exponent of ρ_2. Since the fraction of flux reflected from one wall that reaches the other three walls is identified by the symbol "y," the exponent of y is determined by counting the spaces between adjacent W's. The fraction of flux reflected from the walls that reaches (or passes through) the work plane is designated "z," see Table II. Thus,

$$\begin{aligned} S_1 = \quad & W(WP) = \quad \rho_1 z \\ + \quad & WW(WP) \quad + \rho_1^2 y z \\ + \quad & WWW(WP) \quad + \rho_1^3 y^2 z \\ + \quad & WWWW(WP) \quad + \rho_1^4 y^3 z \\ + \quad & \ldots \quad + \ldots \end{aligned}$$

and the sum of the progression is

$$S_1 = \frac{\rho_1 z}{1-\rho_1 y}$$

The initial path of flux from wall to work plane, $W(WP)$, is the *prime* path, and this is then expanded as shown. The subscript "1" of S_1 refers to Path 1, and is not one of the subscripts 1, 2, and 3, referring to walls, ceiling, and floor respectively. Since all flux reflected to the work plane must be reflected last by either the walls or the ceiling, the condition wherein the wall finally reflected the flux to work plane was attacked first. That is, consideration was given first to flux paths ending $\ldots W(WP)$, rather than to those ending in $\ldots C(WP)$.

It appeared logical to compute first the wall interflectance, f_1, so the above succession of reflections, involving only the walls was the starting point, and $W(WP)$ is Prime Path 1. Building on this foundation an attempt was made to logically establish a systematic procedure for writing the combinations of W and C that are necessary to comprehend every possible path that flux may travel in reaching the work plane and yet make sure that no path was counted more than once. It was also necessary to arrange the combinations in such a manner that the sums formed geometrical progressions, or groups of progressions, so that that sum of them all would be a simple mathematical formula. The formula ultimately obtained represents a rigorous solution for f_1 (rigorous within the confines of the assumptions listed previously, and assuming a black floor). A reflecting floor will be comprehended later.

In Prime Path 2 the flux is reflected from the walls to ceiling to walls to work plane, $WCW(WP)$. Path 2 is then expanded to a greater degree than Path 1, as shown below. The exact manner in which Path 2 is expanded will be used over and over again and will be referred to as a "normal expansion."

	Column I	Column II	Column III
	$WCW(WP)$	$WCWCW(WP)$	$WCWCWCW(WP)$
Row A	$WWCW(WP)$	$WWCWCW(WP)$	$WWCWCWCW(WP)$
	$WWWCW(WP)$	$WWWCWCW(WP)$	$WWWCWCWCW(WP)$
	$WCWW(WP)$	$WCWCWW(WP)$	$WCWCWCWW(WP)$
Row B	$WWCWW(WP)$	$WWCWCWW(WP)$	$WWCWCWCWW(WP)$
	$WWWCWW(WP)$	$WWWCWCWW(WP)$	$WWWCWCWCWW(WP)$
	$WCWWW(WP)$	$WCWCWWW(WP)$	$WCWCWCWWW(WP)$
Row C	$WWCWWW(WP)$	$WWCWCWWW(WP)$	$WWCWCWCWWW(WP)$
	$WWWCWWW(WP)$	$WWWCWCWWW(WP)$	$WWWCWCWCWWW(WP)$

The normal expansion of Path 2 could be carried on out indefinitely, but the sum ultimately obtained would remain unchanged.

The sums of Path 2 are:

Column I, Row A1 $s = \rho_1^2 \rho_2 x u z$

A2 $s = \rho_1^3 \rho_2 x u z y$

A3 $s = \rho_1^4 \rho_2 x u z y$

and the sum for Column I Row A is

$$s = \frac{\rho_1^2 \rho_2 x u z}{1 - \rho_1 y}$$

Similarly, the sum for Column I Row B is

$$s = \frac{\rho_1^3 \rho_2 x u z y}{1 - \rho_1 y}$$

and for Column I, Row C

$$s = \frac{\rho_1^4 \rho_2 x u z y^2}{1 - \rho_1 y}$$

These three sums (plus many more if carried on out) fall into a progression so that the sum for Column I is

$$S_I = \frac{\rho_1^2 \rho_2 x u z}{(1 - \rho_1 y)^2}$$

In a like manner the sums of Columns II and III respectively are:

$$S_{II} = \frac{\rho_1^3 \rho_2^2 x^2 u^2 z}{(1 - \rho_1 y)^2}$$

$$S_{III} = \frac{\rho_1^4 \rho_2^3 x^3 u^3 z}{(1 - \rho_1 y)^2}$$

And the sums of Columns I, II, and III (plus many more) form another progression, the sum of which for Path 2 is:

$$S_2 = \frac{\rho_1^2 \rho_2 x u z}{(1 - \rho_1 y)^2 (1 - \rho_1 \rho_2 x u)}$$

Thus, the sum (formula for any prime path expanded in the *normal* manner is the formula for the prime path divided by $(1 - \rho_1 y)^2 (1 - \rho_1 \rho_2 x u)$. All future prime paths are expanded in the *normal* manner (exactly like Path 2) so considerable effort is saved by the concept of the normal expansion.

Paths 3, 4, and 5 form one progression; 6, 7, and 8 form a second, and 9, 10, and 11 form a third.

Path Number	Prime Path
3	*WCWWCW (WP)*
4	*WCWWCWCW (WP)*
5	*WCWWCWCWCW (WP)*
6	*WCWWWCW (WP)*
7	*WCWWWCWCW (WP)*
8	*WCWWWCWCWCW (WP)*
9	*WCWWWWCW (WP)*
10	*WCWWWWCWCW (WP)*
11	*WCWWWWCWCWCW (WP)*

The sum of these three progressions is:

$$S_{3\text{-}11} = \frac{\rho_1^4 \rho_2^2 x^2 u^2 z y}{(1 - \rho_1 y)^3 (1 - \rho_1 \rho_2 x u)^2}$$

In a similar manner Paths 12 to 14, 15 to 17, and 18 to 20 form three more progressions, and these three progressions are individual terms of another progression, shown as the sum of Paths 12 to 20.

Path Number	Prime Path
12	*WCWWCWWCW (WP)*
13	*WCWWCWWWCW (WP)*
14	*WCWWCWWWWCW (WP)*
15	*WCWWWCWWCW (WP)*
16	*WCWWWCWWWCW (WP)*
17	*WCWWWCWWWWCW (WP)*
18	*WCWWWWCWWCW (WP)*
19	*WCWWWWCWWWCW (WP)*
20	*WCWWWWCWWWWCW (WP)*

$$S_{12\text{-}20} = \frac{\rho_1^6 \rho_2^3 x^3 u^3 y^2 z}{(1 - \rho_1 y)^4 (1 - \rho_1 \rho_2 x u)}$$

In the process of expanding each path in the normal manner additional *W*'s were added in the positions indicated by the arrows 1 and 2 below, and this raised $(1 - \rho_1 y)$ in the denominator to the second power; also, *CW*'s were added at arrow A, introducing $(1 - \rho_1 \rho_2 x u)$ in the denominator. In Paths 13 and 14, 16 and 17, and 19 and 20 additional *W*'s were added, at arrow 3, raising $(1 - \rho_1 y)$ to the third power in the formulas for Paths 12 to 14, 15 to 17, and 18 to 20. Additional *W*'s were then added at arrow 4 in Paths 15 to 17 and 18 to 20, raising $(1 - \rho_1 y)$ to the fourth power in the formula for Paths 12 to 20.

1 A 4 C 3 B 2
↓↓ ↓↓ ↓↓ ↓
W C WW C WW C W (WP)

In Paths 21 to 74 additional *CW*'s were added, first at arrow B, then at arrow C, raising $(1 - \rho_1 \rho_2 x u)$ from the first to the third power, yielding the following formula for Paths 12 to 74:

$$S_{12\text{-}74} = \frac{\rho_1^6 \rho_2^3 x^3 u^3 y^2 z}{(1 - \rho_1 y)^4 (1 - \rho_1 \rho_2 x u)^3}$$

This process can be carried on indefinitely but the cumulative formulas that will be obtained are merely additional terms to the progression already established. Therefore, to solve for that portion of f_1 comprehending all flux reflected to the work plane by the walls only (Paths ending in $\ldots W(WP)$), and assuming the floor is black, it remains only to add the sums of Paths 1, 2, 3 to 11, and 12 to 74. Formulas for Paths 2, 3 to 11, and 12 to 74 form a progression, the sum of which is added to the formula for Path 1.

$$S_{1\text{-}74} = \frac{\rho_1 z}{1 - \rho_1 y - \rho_1 \rho_2 x u}$$

At no time in Paths 1 to 74 was the flux reflected from ceiling to work plane comprehended. To comprehend that, flux Paths 1 to 74 all could be rewritten with a *"C"* inserted between the last *"W"* and the *"WP."* However, it is possible to write the formula for these Paths (which we shall call Paths 75 to 148) merely by inspection, and the sum of Paths 1 to 148 is,

$$S_{1\text{-}148} = \frac{\rho_1 z + \rho_1 \rho_2 x t}{1 - \rho_1 y - \rho_1 \rho_2 x u}$$

This formula comprehends all reflections except those involving the floor, and is a rigorous solution (within the confines of the assumptions for f_1 if the floor is black.

Since the above formula is applicable to rooms having a non-reflecting floor, consideration of a reflecting floor will now be made: Let

$$A = \frac{\rho_1 z + \rho_1 \rho_2 x t}{1 - \rho_1 y - \rho_1 \rho_2 x u}$$

If A represents the flux that ultimately reaches the work

plane, then B represents the flux ultimately reaching the black floor

$$B = \frac{\rho_1 x + \rho_1 \rho_2 x v}{1 - \rho_1 y - \rho_1 \rho_2 x u}$$

If A represents the flux reflected to the work plane and B the flux reflected to the floor in a room with a black floor, then in a room with a reflecting floor, using the letter "F" to designate floor as C and W are used to designate ceiling and walls,

$$\begin{aligned}
f_1 = A &+ BFuA + BFCuA + BFC(WP) \\
&+ BFCFuA + BFCFCuA + BFCFC(WP) \\
&+ BFCFCFuA + BFCFCFCuA + BFCFCFC(WP) \\
&+ \ldots + \ldots + \ldots \\
= A &+ B\rho_3 uA + B\rho_3\rho_2 vuA + B\rho_3\rho_2 vt \\
&+ B\rho_3^2\rho_2 v^2 uA + B\rho_3^2\rho_2^2 v^3 uA + B\rho_3^2\rho_2^2 v^3 t \\
&+ B\rho_3^3\rho_2^3 v^4 uA + B\rho_3^3\rho_2^3 v^5 uA + B\rho_3^3\rho_2^3 v^5 t
\end{aligned}$$

$$f_1 = A + \frac{B\rho_3 uA}{1-\rho_2\rho_3 v^2} + \frac{B\rho_2\rho_3 vuA}{1-\rho_2\rho_3 v^2} + \frac{B\rho_2\rho_3 vt}{1-\rho_2\rho_3 v^2}$$

$$f_1 = A + B\left(\frac{\rho_3}{1-\rho_2\rho_3 v^2}\right)(uA + \rho_2 vuA + \rho_2 vt)$$

Knowing f_1, it is now possible to solve for f_2 as follows:

$$\begin{aligned}
f_2 = &\quad C(WP) + Cuf_1 + CFuf_1 \\
&+ CFC(WP) + CFCuf_1 + CFCFuf_1 \\
&+ CFCFC(WP) + CFCFCuf_1 + CFCFCFuf_1 \\
&+ \ldots + \ldots + \ldots \\
f_2 = &\quad \rho_2 t + \rho_2 uf_1 + \rho_2\rho_3 vuf_1 \\
&+ \rho_2^2\rho_3 v^2 t + \rho_2^2\rho_3 v^2 uf_1 + \rho_2^2\rho_3^2 v^3 uf_1 \\
&+ \rho_2^3\rho_3^2 v^4 t + \rho_2^3\rho_3^2 v^4 uf_1 + \rho_2^3\rho_3^3 v^5 uf_1 \\
&+ \ldots + \ldots + \ldots
\end{aligned}$$

$$f_2 = \frac{\rho_2 t}{1-\rho_2\rho_3 v^2} + \frac{\rho_2 uf_1}{1-\rho_2\rho_3 v^2} + \frac{\rho_2\rho_3 vuf_1}{1-\rho_2\rho_3 v^2}$$

$$f_2 = \left(\frac{\rho_2}{1-\rho_2\rho_3 v^2}\right)(t + f_1 u + f_1 u\rho_3 v)$$

and

$$f_3 = \rho_3(f_1 u + f_2 v)$$

References

1. Harrison, Ward, and Anderson, A. E.: "Coefficients of Utilization," *Transactions of the Illuminating Engineering Society*, Vol. XV, p. 97 (1920).
2. Margoulis, W.: "Etude Nomographique pour la Determination des Coefficients d'Utilisation dans les Projects d'Eclairage," *Rev. Gen. d'Elec.*, p. 439, September 22, 1928.
3. Crouch, C. L., and Freyer, Eve: "New Formula for Room Index," ILLUMINATING ENGINEERING, Vol. XLVIII, p. 203 (1953).
4. Moon, Parry, and Spencer, D. E.: "Light Distribution in Rooms," *Journal of the Franklin Institute*, 242 (1946), p. 111; "Lighting Design by the Interflection Method," *Journal of the Franklin Institute*, 242 (1946), p. 465; *Lighting Design*, Addison-Wesley Press, Cambridge, Mass. (1948).
5. Dourgnon, J.: "Nouvelle Methode de Predetermination des Coefficients d'Utilisation dans le Projets d'Eclairage et de Chauffage," *Rev. Gen. d'Elec.*, 23 (1928), p. 271.
6. Dourgnon, J., and Cadiergues, R.: "Sur l'Application de l'Equation de Fredholm a l'Etude des Problem d'Eclairage et de Chauffage," *Rev. Gen. d'Elec.*, 58 (June 1949), p. 229.
7. Churchill, R. D., and Putnam, R. C.: "Verification of the Interflection Tables," ILLUMINATING ENGINEERING, Vol. XLVI (1951), p. 453.
8. Jones, J. R., and Neidhart, John J.: "A Comparison of Measured and Calculated Coefficients of Utilization," ILLUMINATING ENGINEERING, Vol. XLIX (1954), p. 127.
Potter, W. M., and Russell, A. H.: "Measured Utilization Factors II," ILLUMINATING ENGINEERING, Vol. L (1955), p. 177.
Wiseman, R. S.: "Brightness and Illumination by Interflections in Enclosures," ILLUMINATING ENGINEERING, Vol. L (1955), p. 227.
9. Potter, W. M., and Russell, A. H.: "Measured Utilization Factors," ILLUMINATING ENGINEERING, Vol. XLIX (1954), Table V, p. 145.
10. Moon, Parry: *Scientific Basis of Illuminating Engineering*, McGraw-Hill Book Co., New York, N. Y. (1936).
11. Jones, J. R., and Neidhart, John J.: "Coefficients of Utilization for Luminaires with Concentrating Distributions," ILLUMINATING ENGINEERING, Vol. XLVI (1951), p. 601. "The Zonal Method of Computing Coefficients of Utilization and Illumination on Room Surfaces," ILLUMINATING ENGINEERING, Vol. XLVIII (1953), p. 141.

DISCUSSION

DOMINA EBERLE SPENCER:* The procedure developed by Jones and Neidhart is ingenious and must have required a great deal of work. The paper shows that, over a considerable range of room shapes and reflectances, the new algebraic method agrees with the integral equation solution and with experiment.

There are, however, inherent differences between the Moon-Spencer solution of the interflection problem and the Jones-Neidhart solution.

(a) In the former, the helios (brightness) of the wall is non-uniform; Jones and Neidhart make the unrealistic assumption that the helios of the wall is always uniform. (b) Jones and Neidhart employ the exact flux ratios found in Table XXXIX on page 343 of Professor Moon's "Scientific Basis of Illuminating Engineering"; Professor Moon and I make extensive use of exponential approximations.

The net result of these two differences in initial assumptions is to make the J-N equations more accurate than the M-S interflection equations in the special case in which there are no interflections and only direct light is to be considered. But the interflection method was never intended to be used for the calculation of the distribution of light in black rooms where no interflections are possible.

On the other hand, the assumption of uniform walls in the Jones-Neidhart equations gives serious trouble for the important case in which reflectances are high and interflections are predominant. The J-N procedure gives a pessimistic evaluation of the interflected component of the light.

The largest discrepancy between the two methods occurs if we take a room with black walls and floor. Assume a ceiling reflectance of 0.80 and luminaires that send all their light to the ceiling. Values of f_2 are:

	$k_r = 1$	$k_r = 2$
Jones-Neidhart	0.227	0.089
Moon-Spencer	0.178	0.040

The J-N values which are calculated by the exact method given in "Scientific Basis" are correct. The M-S values are approximate and are obtained from the exponential approximation

$$f_2 = \rho_2 e^{-2k_r h 1/h}$$

Now consider the same rooms with a white wall of reflectance 0.80 and a light floor of reflectance 0.30. The new values of f_2 are

	$k_r = 1$	$k_r = 2$
Jones-Neidhart	0.560	0.237
Moon-Spencer	0.570	0.296

The J-N values have become lower than the M-S values because of the incorrect assumption that the brightness of the walls is uniform. In fact, if we subtract that part of f_2 which corresponds to light coming directly from the ceiling to the work we find that the interflected components differ even more:

*University of Connecticut, Storrs, Conn.

	$k_r = 1$	$k_r = 2$
Jones-Neidhart	0.333	0.148
Moon-Spencer	0.392	0.256

Probably the most exact method of calculating f_2 in this example would be to use the exact expression for the direct component of f_2 and the Moon-Spencer expression for the interflected component of f_2 giving

$k_r = 1$	$k_r = 2$
0.619	0.345

Now let us try out this procedure of correcting the interflectance as given in Table 5.03 of Moon and Spencer's "Lighting Design" by replacing the exponential approximation for the direct light from the ceiling by the exact expression, to obtain new values to compare with the Potter and Russell data quoted in Jones-Neidhart's Table I. If we assume that the luminaires send 75 per cent of their light to the ceiling, we obtain

k_r	Moon-Spencer f	Corrected Moon-Spencer f	Experimented f	Per Cent Error
1.2	0.210	0.247	0.251	1.2
1.033	0.259	0.296	0.300	1.6
1.033	0.265	0.302	0.304	0.7
0.825	0.339	0.369	0.378	2.4
0.825	0.349	0.379	0.380	0.3
0.700	0.411	0.437	0.438	0.2

Note that the discrepancies between the corrected Moon-Spencer values and the experimental values are never more than 2.4 per cent, while the residual discrepancies between the Jones-Neidhart values and the experimental values are between 3.6 and 6.7 per cent.

Thus, we can make two conclusions:

(1) The Jones-Neidhart method is more exact than the standard interflectance tables in the special case of black broom closets. But this is not of practical importance.

(2) If greater accuracy in the calculation of the distribution of light in empty rooms is desired, the standard interflectance tables can be made more accurate by replacing the exponential approximations used in calculating direct light from wall or ceiling by exact expressions, while continuing to employ the exponential approximations for the interflected component. The change would be negligible for the important range of large rooms with $k_r < 1$, but would become appreciable for cubical rooms and for broom closets. As the interflection tables stand, they are slightly conservative in their prediction of coefficients of utilization for small rooms with ceiling lighting. This may actually be a practical advantage in tending to compensate for the effect of furniture.

PHELPS MEAKER:* From an overall look at this work, it seems as though the first remark might be "The impossible just takes a little longer!" The authors have certainly introduced a fresh aspect to the analysis of flux transfer. Things will start buzzing as interested members begin to try out this method and subject it to various forms of analysis.

Regarding indirect lighting, which the authors use to compare their data, Moon and Spencer interflectance data, and measured utilizations, the statement is made that the residual differences of 3 or 4 per cent are probably due to a non-uniform ceiling brightness. We believed, however, that the greater part of the 16 per cent difference between measured and Moon and Spencer values was due to this non-uniform brightness; variations of about 3 to 1 between maximum and minimum were involved in the test room. Measurements with more nearly uniform brightness (Reference No. 7) showed far less difference.

But if the described method matches measurements better, when an indirectly lighted ceiling is non-uniform — when one of the assumptions is violated — what will it do for a uniformly bright luminous ceiling? I can foresee that the published discussion will have plenty of reference to that subject.

As Dr. Spencer mentioned, the assumption of uniform final surface brightness is a serious business, and presumably this means also that the surface brightness has to be assumed uniform after each successive reflection. Take a luminous ceiling in a typical room with fairly dark floor; the first incidence of flux from ceiling to wall does not produce uniform brightness on the latter. With the highest values at the top, the wall brightness is less effective in producing work-plane illumination than a uniform wall would be. It seems as though an analysis of this is needed before we can subscribe to something that departs so far from what we are accustomed to, both in calculations and in practice.

A great deal depends on those relationships between the fractions t, u, z, y and z. For the special case where $k_r = 1.0$, they are clear enough, because of the simple apportionment of reflected flux; however, there needs to be a derivation or at least rationalization of these for the general case, in order that one may not carry the idea that the relationships as a whole are on the order of assumptions. I have particular reference to the equations:

$$x = u \frac{\text{ceiling area}}{\text{wall area}} \text{ (equal also to } u/4k_r\text{), and}$$

$$z = (1.0 - t) \frac{\text{ceiling area}}{\text{wall area}}.$$

Relative to the latter formula, is the wall area involved that of the total wall, or just the fraction above the work-plane? If the latter were to be preferred, the data on indirect utilization discussed previously will be substantially changed. Where the computation is stated to be 3.6 per cent *less* than the measured value, such a revision of the formula for z would give an answer about 5 per cent *more* than the measurement.

PHILIP F. O'BRIEN:* This paper outlines a method for the prediction of luminous flux distribution in rooms which exhibit axial symmetry. The method of summation of infinite series of reflected fluxes, which has long been employed to describe the performance of the integrating sphere and infinite room, is extended to the case of a rectangular room. The authors have applied this well-known method of infinite-series summation to the more difficult geometry of the rectangular room by developing an orderly notation. The application of this method to rooms that must be represented by several more surface elements than are considered here will certainly test the inventiveness and patience of the researcher.

A dimensionless geometrical parameter, which is designated by the symbols t, u, v, z, y and z is not specifically named by the authors but is apparently related to Yamanti's flux function as reported by Moon.[1] Using Moon's notation,[1]

*General Electric Co., Cleveland, Ohio.

*Department of Engineering, University of California, Los Angeles, Calif.

Yamanti's parameter has the dimensions of luminous flux, as follows:

$$F_{23} = L_2\left[\frac{1}{\pi}\int_{A_3}\int_{A_2}\frac{\cos\theta_2\cos\theta_3}{r^2}\,dA_2\,dA_3\right] \tag{1}$$

$$F_{32} = L_3\left[\frac{1}{\pi}\int_{A_3}\int_{A_2}\frac{\cos\theta_2\cos\theta_3}{r^2}\,dA_2\,dA_3\right]$$

where F_{23} = the luminous flux which leaves the uniform diffusely emitting ceiling A_2, which is *initially* intercepted by floor, A_3; (lumens).

F_{32} = lumens from floor to ceiling.

$\cos\theta_2, \cos\theta_3$ = the cosines of angles formed by a ray from the surface with respect to a normal ray.

L_2, L_3 = total uniform luminous emittances of surfaces A_2 and A_3, respectively (lumens/ft^2).

The above equations may be rewritten so as to relate the authors' notation with that used by Moon in Reference 10 of their paper

$$F_{23} = L_2 A_2 v \tag{2}$$

$$F_{32} = L_3 A_3 v$$

where by reference to Equation (1),

$$v = \frac{1}{\pi A_{2-3}}\int_{A_3}\int_{A_2}\frac{\cos\theta_2\cos\theta_3}{r^2}\,dA_2\,dA_3 \tag{3}$$

Another notation for v which is commonly used in the area of radiant-power transfer is

$$vA_2 = vA_3 = F_{2\to3}A_2 = F_{3\to2}A_3 \tag{4}$$

Equation (4) is the reciprocity theorem for flux transfer which is employed by the authors to develop relationships for x and z.

The shape modulus, $v = F_{2\to3}$, as defined by Equation (3) is a dimensionless parameter which is a powerful tool for the solution of many problems in lighting and radiant-power transfer. Some literature that outlines the analytical and empirical evaluation of the shape modulus was recently reviewed by O'Brien.[2]

In a cubical room of domance or k_r equal to unity, v is equal to 0.2 as shown by the authors' Fig. 4. As pointed out by Jones and Neidhart, the work of Moon and Spencer on interflections includes an exponential approximation of v for a cubical room as follows:

Moon & Spencer $\qquad v = F_{2\to3} = e^{-2k_r} = 0.135$

Jones & Neidhart — Yamanti $\qquad v = F_{2\to3} = 0.200$

As suggested by the authors' expressions for the interflectance values f_1, f_2 and f_3, the geometry of a room may be represented by a set of shape moduli (i.e., t, u, v, x, y and z) rather than by a single parameter such as the room index or domance. When lighting is designed for rooms that do not exhibit axial symmetry with respect to flux input or reflectance distributions, the specification of room geometry by a set of shape moduli may prove to be more useful than by the room index.

The authors are to be commended for this original contribution to the analytical methods of lighting design. Rapid advances in lighting techniques and more exact specifications of the lighting environment as required by the owner seem to preclude the use of outmoded or limited empirical data which has been the principal tool of routine lighting design for nearly forty years.

1. Moon, Parry: "Scientific Basis of Illuminating Engineering," McGraw-Hill Book Co., New York, 1936, pp. 334-344.
2. O'Brien, P. F.: "Network Representation of the Integrating Sphere," *Journal of the Optical Society of America*, Vol. 46, No. 5, pp. 343-345 (May 1956).

J. R. JONES and JOHN J. NEIDHART:* We appreciate the time each of the discussors spent studying our paper and preparing discussion. Often the discussors bring out points that had not previously been considered, and along with the rebuttal, constitute something similar to a successful "brainstorming session" with a resultant broadening for all, but particularly for the participants.

For example, Dr. Spencer's discussion suggests a distinct improvement in the interflectance method. Coming from the author as it did, we feel her suggestion should be taken seriously by the users of that method. While she feels these high narrow rooms, to which it primarily applies, are unimportant, there are nevertheless many of them in industry and usually they are badly in need of lighting.

We feel her suggestion is an excellent one even though in her tabular data she apparently used the wrong ceiling ratio (0.75 instead of 0.803) for the three rooms for which she showed percentage errors of 0.7, 0.3 and 0.2 per cent. Had she used the correct ceiling ratio for these three computations her percentage error would still have been within three per cent, showing excellent accuracy.

We appreciate her data showing perfect accuracy for the Algebraic Method for high narrow rooms ($k_r = 1.0$ and 2.0) with black walls and floor. But we cannot understand where she obtained the f_2 values for the Algebraic Method when the room surface reflectances were raised to 80 per cent for the ceiling and walls and 30 per cent for the floor. Our own computations show the correct figures to be higher, especially for $k_r = 2.0$. We find the correct value to be 0.344, remarkably close to the corrected Moon-Spencer value of 0.345.

Nearly all of Dr. Spencer's critical comments stemmed from her apparent error in this computation because it led her to believe the Algebraic Method loses all accuracy if reflectances are high and the room shape is high and narrow. We admit there is reason to wonder how the departure from the assumed conditions will affect the accuracy in these "white broom closets," but on the basis of computations made thus far it appears the accuracy is good. Both Dr. Spencer and Mr. Meaker questioned the assumption of uniformity of final wall brightness. We all realize the final wall brightness will be greater near the top of the wall in a ceiling lighted room. The error that is introduced is zero if k_r is zero, and reaches a maximum if k_r is great. When k_r is 2.0, it would not be unreasonable to expect a significant error. However, in the example brought up by Dr. Spencer, the Algebraic Method yields a value almost identical with the corrected Moon-Spencer value which does comprehend a variation in wall brightness. Primarily on the basis of this we feel the error is not great. As a matter of interest, Professor O'Brien's method, discussed later, yields a value of 0.346.

Earlier in Mr. Meaker's discussion he raised the question of the source of the 16 per cent error shown in Table I. Computational processes are available for making an accurate analysis if the assumptions on which the calculations are based are all met. But since they are almost never met completely, practical tests are necessary to measure illumination so that the measured value can be compared to the computed value. The errors may then be ascribed to deviations from the assumed conditions. Mr. Meaker felt the 16 per cent error originally reported by Potter and Russell, and reported in Table I, could be ascribed to a non-uniformly bright ceiling. Convincing evidence was offered by Dr. Spencer's discussion that most of the error was caused by extremely conservative f_2 values. It is true that a non-uni-

*Authors.

formly bright ceiling will yield higher illumination than one that is uniform in brightness. But we feel the error from this cause in Potter and Russell's measurements did not exceed, at most, about 5 per cent. For support of this belief we would like to suggest the use of direct ratios computed for the 1.0 spacing-to-mounting height ratio for a cosine distribution luminaire which would represent, not a mere three-to-one variation in ceiling brightness, but the very maximum. For the room ratio of 0.75 where this 16 per cent error occurred we find a difference of only 11 per cent between this direct ratio and one for a uniformly bright ceiling. We may also compare the direct ratio computed for a 0.4 spacing-to-mounting height ratio to the direct ratio computed for a uniformly bright ceiling. This time the difference between them is only about 3 per cent. The 0.4 spacing ratio approaches a luminous ceiling because the luminaires are so close together. This leads us to believe a mere three-to-one ratio in ceiling brightness would not cause a variation of anywhere near 16 per cent.

With reference to the symbols and their inter-relationship, Mr. Meaker asks if the wall area involved is that of the total wall. Yes, it is. These relationships were developed as follows:

Derivation of $x = u$ (ceiling area/wall area)

Let

L_1 = luminosity of walls (footlamberts)

L_2 = luminosity of ceiling

$N_{1\to 2}$ = number of lumens emitted by the walls that strike, initially, the ceiling

$N_{2\to 1}$ = number of lumens emitted by the ceiling that strike, initially, the walls

then

$$x = \frac{N_{1\to 2}}{L_1 \text{ (wall area)}}$$

$$u = \frac{N_{2\to 1}}{L_2 \text{ (ceiling area)}}$$

and

$$\frac{x}{u} = \left(\frac{N_{1\to 2}}{L_1 \text{ (wall area)}}\right)\left(\frac{L_2 \text{ (ceiling area)}}{N_{2\to 1}}\right)$$

Now let $L_1 = L_2$. The principle of reciprocity states that if $L_1 = L_2$, then $N_{1\to 2} = N_{2\to 1}$. Therefore, $x = u$ (ceiling area/wall area).

The "brainstorming" aspect of our three discussors takes another step in Mr. Meaker's discussion. He states that presumably the assumption of uniform final brightness means also that the brightness has to be assumed uniform after each successive reflection. As we analyze our method, we agree. But after comparing the results obtained by Professor O'Brien's work we reach the conclusion that one need not necessarily make this assumption to compute the same interflectance values.

O'Brien solves the following formulas by a network computer in a matter of seconds, notation converted to terms of this paper:

$$L_1 = L_{01} + \rho_1 (yL_1 + xL_2 + zL_3)$$
$$L_2 = L_{02} + \rho_2 (uL_1 + vL_3)$$
$$L_3 = L_{03} + \rho_3 (uL_1 + vL_2)$$

In solution let two of the three of L_{01}, L_{02} or L_{03} (initial brightness of walls, ceiling and floor respectively) equal zero and assign a value to the third. Therefore, there are only three unknowns and there is a firm solution. Introduction of our exact symbols (u, v, x and y) necessarily implies uniformity of final brightness of room surfaces; however, different values of the symbols could be computed, each based on a variation in final brightness.. Solution of these equations ultimately yields a value of 0.346 for f_2 in room shape $k_r = 2.0$, $\rho_1 = \rho_2 = 0.80$, and $\rho_3 = 0.30$, as in the example discussed earlier in connection with Dr. Spencer's comments.

At first observation it would appear that in each of the three equations above, the x's and the u's should be interchanged. This apparent switch is caused by the principle of reciprocity.

The most wonderful thing about Professor O'Brien's computer is that it can solve for ten or twelve unknowns as additional equations are written, each comprehending a portion of the room having a different initial brightness or reflectance. For example it can comprehend such things as a dado, carrying ceiling color down a portion of the walls, consideration of windows, ceiling beams, etc. Indeed, the technique presents a most powerful tool.

In the examples tried so far (using our values for the symbols) the above equations yield the same values of interflectance as the Algebraic Method. In completing solution for interflectance, $f = L_2 t$ (ceiling area) $+ L_1 x$ (wall area), divided by the lumens input into the installation.

Again we would like to express our appreciation to each of the discussors of our paper.

I.E.S. Emblem

The official emblem of the Illuminating Engineering Society is available to members in 14-karat gold, lapel screw back buttons, in the miniature ½-inch size, at only $3.50 each including taxes. Background of emblem is blue for Members, red for Associate Members. Emblems may be ordered from the General Office, Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.

INSTALLATION AT CENTURY ELECTRIC CO., 1806 PINE ST., ST. LOUIS, MO.

Lighting a Motor Winding Line

LIGHTING OBJECTIVE: To illuminate the interiors of electric motor stators by luminaires positioned such that men working on one line are not bothered by glare from the luminaires over the next line.

GENERAL INFORMATION: The two wiring lines shown above are about six feet apart. Ceiling height is approximately 13 feet. The units being wired here are hermetically sealed motors requiring a high degree of quality control. During wiring operations, workers cast partial shadows over the motors. Colors and reflectances of room surfaces are as follows:

ceiling	white	75% RF
end wall	off-white	65% RF
painted windows	off-white	50% RF
brick wall	red	15% RF
floor	gray	8% RF
bench top	gray	10% RF
motor frame	black	1% RF
motor winding	white	75% RF

(over)

A.I.A. File No. 31

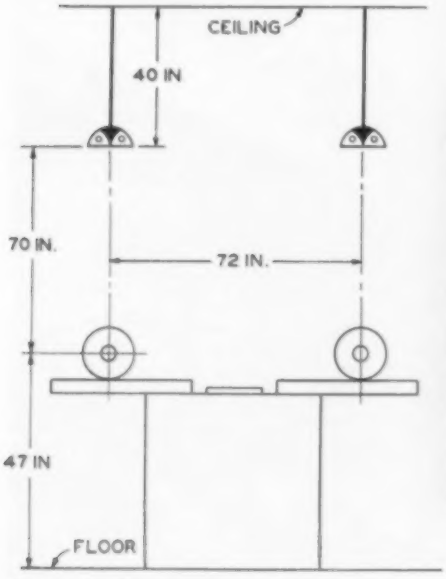


Figure 2. Cross-section showing mounting of luminaires relative to the work.

Figure 3. The area at the left is lighted by old-style solid-top luminaires. Note the improvement at right in appearance of same ceiling above luminaires with 25 per cent upward component of light.

INSTALLATION: Two 56-foot long rows of Day-Brite No. 41252 two-lamp industrial luminaires with a 25 per cent upward component of light are installed as indicated in Fig. 2. These contain 40-watt cool white rapid start fluorescent lamps. (The rigid eight-foot chassis requires suspension at the ends only.)

Illumination is 80 footcandles on the bench tops and 30 footcandles inside the stators while they are being wired. The reflector design provides 30-degree shielding, and luminaires are positioned such that workers on one side of the bench cannot see the lamps of the luminaires opposite them. Brightnesses are as follows:

ceiling	18 ft-L	floor	5 ft-L
end wall	20 ft-L	bench top	8 ft-L
painted windows	15 ft-L	motor winding	45 ft-L
brick wall	8.5 ft-L	luminaires crosswise at 30 degrees	450 ft-L

Fig. 3 shows the improvement in appearance of the ceiling resulting from the use of luminaires with a 25 per cent upward component of light. The ceiling in the area at the left lighted by old-style solid-top industrial lighting units has the same reflectance as the relighted area at the right.

Lighting designed by Ora Fleischer, E. H. Lauth and Associates, Inc., St. Louis, Mo.

Lighting data submitted by Ora Fleischer as an example of good lighting practice and to aid in the design of similar installations.

Published by the Committee on Publications of the Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.

Assessment of Brightness:

What We See

By R. G. HOPKINSON

It was an honor to be invited to address the Illuminating Engineering Society at its 50th Anniversary Convocation, and one which I deeply appreciated. When I was asked to address the Society I thought of what might be the most suitable subject to choose from the various investigations in which we are engaged at the Building Research Station at the moment. I felt that a Fiftieth Anniversary Convocation was the kind of special occasion which calls either for a review of what has been done in the past, or a description of work which might lead to something new in the future. I decided to try to fulfill the second requirement. The subject I have chosen is the Assessment of Brightness — the problem of the judgment of magnitude of brightness as we see it.

In order to understand what the problem is, try to go back to the days before you became professionally interested in lighting and remember how you used to think of brightness in those days. When I first went to work (on street lighting), it seemed to me that once I had learned to use a photometer it gave me results which did not accord with what I could see. The brightness of a road sign on a lighted street at night, might measure ten footlamberts, and yet seem to me to be "as bright as day"; even though I knew that the daylight sky was at least one hundred times as bright. Now what was wrong here? Why was it that the photometer was not telling me the story which my eyes were telling me? It did not make sense. I felt this discrepancy perhaps more keenly than my colleagues did, because my first job as a post-graduate student was to develop a technique for the true representation of street lighting installations. To achieve this it was necessary to represent the brightness seen on the street by the same "apparent brightness" when the photograph was viewed in a room. That is why this work on the apparent brightness was initiated. It has been going on intermittently for the last twenty years and we certainly have not finished yet.

Figs. 1 and 2 show two pictures of a classroom by daylight and by artificial light. A comparison of the appearance of the classroom by daylight for example, with a similar classroom by artificial light—walls, ceiling and sky, desk tops and so on—shows that the apparent brightness of the walls is about the same as it was by day. Photographs, of course, are not the same as the reality, but perhaps taken together with personal experience of these situations, they do illustrate my point. Luminance measurements made by a physical brightness meter show that in daylight the wall has a brightness of about 72 footlamberts, the sky about 2000 ft-L, desk tops about 40 or 50 ft-L, and so on. Luminance measurements in the room by artificial light show that the walls have a luminance of only about 3 or 4 footlamberts, and yet to the eye they appear to be almost equally bright as they did by day. Now, the photometer clearly is telling a different story than the eye. Why is this? This is the problem. It is a real one for us lighting engineers and for others too, such as the architect, who wants to have a measure of What We See. With this picture in your mind I want to go on and to describe our work.

Lighting is a technology in which the relation between physical energy and the visual sensory reaction is of prime importance. Photometry would be impossible without the basic Relative Luminous Efficiency function for the Standard Observer. This basic stimulus-sensation relation enables us to build a scale of photometric units in terms of the energy of the stimulus. A brightness scale derived in this way fails to take into account certain basic facts of vision.

First, the visual mechanism at any one moment can register as a sensation only a limited range of energy stimulus. Consequently, a finite but small amount of energy reaching the eye may cause no sensation of light. It is below the "threshold of sensation" for the given conditions, and on a true subjective scale it should be rated as zero.

An invited paper presented at the 50th Anniversary Convocation, National Technical Conference of the Illuminating Engineering Society, September 18, 1956, Boston, Mass. AUTHOR: Dept. of Scientific and Industrial Research, Building Research Station, Garston, Herts, England.

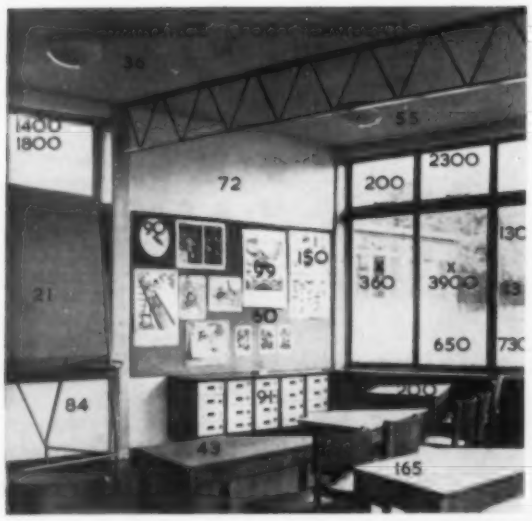


Figure 1. Photograph of a room by daylight, with values of luminance measured by a physical photometer.

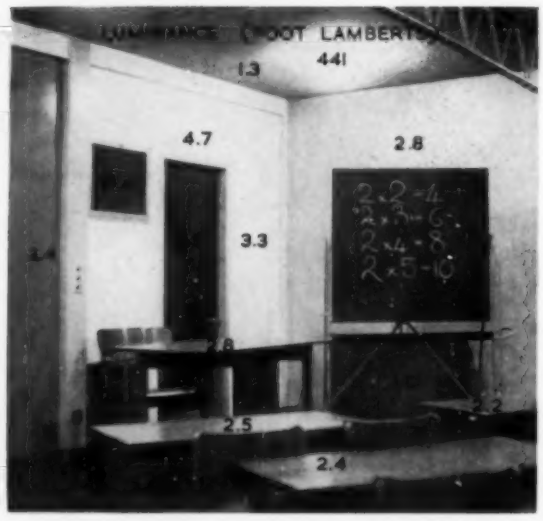


Figure 2. Photograph of a room by artificial light, with values of luminance measured by a physical photometer.

Second, the visual mechanism can accept only a limited amount of energy on a given occasion—too much saturates the mechanism, and there is a sensation of blinding light or of pain.

Third, the sensation of brightness which results from a given stimulus depends on the environment in which it is seen. In a dark environment, stimuli seem brighter than they do in a bright environment. There is thus an "adaptation" effect which results in the subjective brightness being determined, not only by the energy of the stimulus, but also by the energy in the surround areas.

Fourth, the increment of energy which causes a given apparent change in brightness varies systematically in a non-linear manner, so that equal changes in luminance do not normally produce equal changes in subjective brightness.

Fifth, there is an uncertainty and a hysteresis in the stimulus-sensation relation which precludes the establishment of a simple and definite statement of the relation.

Need for a Scale of Subjective Brightness

A scale of subjective brightness is necessary whenever we need to interpret the physical constants of a lighting installation in terms of What We See. A street lighting engineer, for example, in speaking of a "bright" road surface, has values of the order of one footlambert in mind, whereas these values to a daylight consultant are about the threshold of darkness. Both engineers have built up by experience a subjective scale which they automatically employ when thinking about their job.

Difficulties arise when the same job may embrace two or more levels of luminance, for example an art gallery in daylight and in artificial light. Some means is needed for ensuring that the effect, the *subjective* effect, is exactly what is required in both sets of conditions.

The first extensive use of the concept of apparent brightness followed on the derivation of a scale of apparent brightness which took adaptation levels into account (Hopkinson 1939, Stevens and Waldram, 1941). This scale was used at first for the solution of problems of photographic reproduction, and later applied to a study of street lighting visibility. Later still for wartime visibility problems (Stevens and Waldram 1946, Hopkinson 1946). After the war, the concept was applied either in general or specific form to the lighting of buildings. (Hopkinson 1948, Bickerdike and Allen 1951, Hopkinson 1951). Waldram (1954) has used the scale as an essential feature of a method of lighting design which he calls "Designed Appearance" in which the architect is expected to specify the brightness sensation to be given by any part of the visual field in terms of apparent brightness, and this, with the aid to the Hopkinson 1941 data is converted into luminance, and thence to illumination, reflection factor and light distribution.

In the work at the Building Research Station it was always borne in mind that the universal validity of the 1941 data could not be assumed, since these data were built up from contrast rather than

brightness estimation, as will be described later. Situations has arisen which showed that a direct application of the 1941 apparent scale would give misleading results. A series of experiments were put in hand in 1949 to investigate these discrepancies, which confirmed the limitations of the data but which unfortunately had to be left incomplete (Hopkinson 1951).

This gives briefly a picture of the historical background to the present work, up to the point where I was able to visit Professor S. S. Stevens at Harvard University in April 1956 and discuss the problem of brightness assessment with him.

Determination of a Scale Of Subjective Brightness

The classical work on the relation between brightness stimulus and sensation is, of course, that of Weber and of Fechner. From the experimental statement by Weber, that just noticeable differences in sensation result from equal ratios of stimulus, came the Fechner deduction that equal intervals in sensation are proportional to equal ratios of the stimulus. There have been attempts to formulate a subjective brightness scale by the Weber-Fechner method. Abribat (1935) produced such a scale in an attempt to solve the problem of true photographic reproduction of luminosities. It was Abribat's scale, and its evident failings, which served as the starting point for the present work.

By far the greater number of early attempts to formulate a working subjective brightness scale derive from the indirect approach of Fechner, which depends on the assumption that all just noticeable differences, wherever or whenever they occur, are equal. More recently this approach has given ground to the multitude of determinations based on methods of doubling, halving, or other fractionation and multiplication, of which one of the earliest examples is that of Merkel (1888, 1889).

Judgments of subjective brightness using a binocular matching method were made by Pitt (1939) from which a subjective brightness scale could be constructed, but the conditions of observation were not comparable with those which arise in normal problems of illuminating engineering. Craik (1938, 1940), made an extensive study of the effects of adaptation on subjective brightness, without formulating an engineering scale. Hunt (1953) derived a set of "characteristic curves of the human eye" from Craik's and other data in order to assist in the solution of photographic reproduction problems. The enormous body of work by S. S. Stevens and his collaborators will be referred to later.

Experimental Methods for Deriving An Apparent Brightness Scale

Method 1 — Contrast Scaling

The need for a subjective brightness scale became acute in the period immediately before the war, when research on photographic reproduction and on street lighting demanded the assessment of brightness in terms which expressed directly the sensation of brightness being received by the observer. The data of Abribat were examined for these purposes, and found to give a general picture which accorded well with practice, but they were too scanty to give an adequate basis for a complete scale of apparent brightness. A new determination was made using a method known as the "Contrast Ladder," or perhaps better called "contrast scaling."

The essential feature of the method was the successive adjustment of two patches, seen in an adapting field, to appear always of equal contrast one with the other. The two square patches, each of 1° side and separated by 1°, were seen in an adapting field covering most of the field of view. The two patches were first set each to appear black to the observer. The experimenter adjusted the luminance on one (say patch B) of the comparison patches until a contrast well above threshold, perhaps about five just noticeable difference steps resulted with the other (black) patch. The subject was asked to note and remember the contrast between the two patches. The subject now himself adjusted the black patch (patch A), raising its brightness until the contrast with the other patch was the same as before, patch A now being the brighter of the two. Thus two steps of the "contrast ladder" had been established, the first given by the experimenter and the second set by the subject himself. The subject was now asked to bring up patch B until it was brighter than patch A by the same contrast as before, and so on. Thus was the "contrast ladder" built up.

Observations were made by this means at several adaptation levels (*i.e.* settings of the luminance of the surround field). The data were in general consistent. The experimental data were faired and compared with the data of Abribat (1935). (At the time that these studies were actually in hand, 1937, the data of Pitt, 1939, and Craik, 1938, 1940, were not available. There was a long gap between the work and its publication, due to the author being caught up in the march of events).

The agreement was good. The curves shown in Fig. 3 were drawn up from the experimental data and from the data of Abribat, taking Abribat's data to determine the basic shape of the curves,

and the experimental data to fill in the gaps. Abribat's data were not really necessary here, but perhaps in those student days there was a certain lack of confidence when working in a field where many pitfalls were only too clearly delineated by more experienced workers.

The scale of Apparent Brightness was an arbitrary one. It was, of course, a scale of contrast, but it was argued that two luminances each of which appeared, for example, five steps on the contrast ladder brighter than black, would have the same apparent brightness. The scale was deliberately not called a scale of sensation, as had been done by Abribat, but it would perhaps have been better if it had been labeled Contrast. The numerical scale was chosen so that one unit represented approximately a "just noticeable" or perhaps more accurately "just certainly perceptible" contrast, under the experimental conditions. At the time that the scale was first made available (in 1937), a warning was given that, since the scale had been built up from contrast and not from brightness judgment, it would not necessarily represent brightness accurately. It was, however, used for a wide range of visibility problems before and during the war, and, provided the conditions in which it was used compared with the experimental conditions in which it was determined, it gave satisfactory assessments of the subjective impressions of the contrast between adjacent areas in the field of view.

Method 2 — Luminosity Photometer

The use of the concept of apparent brightness in the lighting of buildings was described at a Conference on Lighting and Color of the Council of Industrial Design in London (Hopkinson 1948), but already at that time certain difficulties in the use of the scale had become evident. One was that the values of apparent brightness on the scale did not always correlate with subjective judgments of highlight and shadow; the other was that high luminances did not always appear to have the values of apparent brightness given to them on the scale. The fact that these discrepancies had not been detected before was undoubtedly due to the pre-war and wartime work being concerned almost entirely with low luminance and low adaptation levels, where the scale worked well.

Provided one was aware of these discrepancies, the scale could still be useful, and was employed in many practical situations. In the lighting of art galleries, it had been found empirically that pictures could be seen and enjoyed better by giving preferential lighting to the pictures and reducing the brightness of the general surroundings (Bickerdike and Allen, 1951). The magnitude of the effect

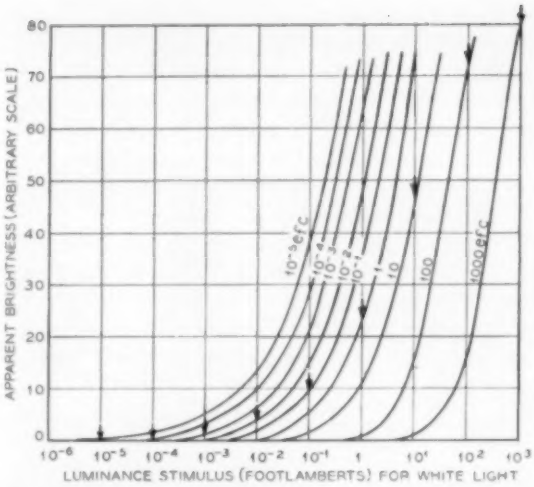


Figure 3. Scale of Apparent Brightness determined from Contrast Scaling Technique (Hopkinson 1939, 1941). Each curve relates the physical brightness stimulus (luminance) with the corresponding subjective brightness magnitude for a given adaptation level.

in different circumstances could be predicted by the use of the apparent brightness scale.

The use of the scale made one more sensitive to brightness relationship in the field of view, and with experience came a greater awareness of discrepancies. It was always realized that a simple dual relation between physical stimulus and sensation could not exist, because of the inherent hysteresis of the sensation-stimulus mechanism, but the discrepancies were often greater than could be accounted for by this explanation.

It was therefore decided to examine the scale by a series of cross-sectional judgments, *i.e.* to see if luminances to which the scale had assigned the same apparent brightness in a range of adaptation conditions were actually judged to have the same apparent brightness. This was therefore a direct check on the basic assumption that an equal number of steps on the "contrast ladder" would always yield the same apparent brightness.

The apparatus used was called the Luminosity Photometer, Fig. 4. It consisted of two identical compartments set side by side with a viewing aperture in each, so that the subject could view the one or the other as he pleased. The interiors of each compartment were white and illuminated uniformly by screened lamps. At the far end of each compartment was a square field patch subtending 3° side at the subject's eyes, and illuminated independently of the surround field. The subject could thus compare the apparent brightnesses of the two field patches, set in different surround luminances,

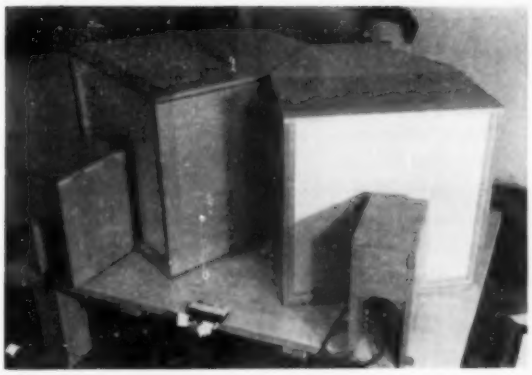


Figure 4. The luminosity photometer. Two identical compartments, side by side, enable the subject to view a patch of light in the one or in the other. The adapting conditions in the two compartments are different, and the task of the subject is to set one of the patches to appear of the same brightness magnitude as the other.

using normal binocular vision, much as he would be able to compare the luminosities of two pictures in adjacent galleries when standing in the communicating door between. The disadvantages of the method were appreciated, especially the need to pause to adapt when changing the view from one compartment to the other, but it was felt that the advantages outweighed them. The method of Hess and Pretori (1894) was considered, but it was felt that the visual difficulties associated with the different planes of presentation would influence the results and that the method gave more weight to simultaneous contrast than to adaptation effects.

The task of the subject was to set the apparent brightness of the two test patches to be equal. Several methods of observation were tried, and much time was spent, as an exercise, in the study of these various methods, including that described by von Bekesy (1947) and Oldfield (1949).

As a result a great deal of information was gathered about the accuracy of different methods of brightness judgment which has come in useful in many connections, but unfortunately the work had to be abandoned for more urgent matters before sufficient data had been gathered to enable a new scale of apparent brightness to be derived. The results confirmed the discrepancies in the high luminance regions of the Hopkinson 1941 scale, however, and also explained why contradictory estimates of apparent brightness were occasionally given. It was found, for example, that simultaneous contrast could upset the basic relation to a marked degree. Also, if the surround luminance in the left hand compartment was almost a photometric match with the patch, *e.g.* 10 footlamberts for the surround and 11 footlamberts for the patch, it proved very difficult for the subject to set the patch in the right hand compartment. Suppose the surround luminance in this compartment was one footlambert, the tendency would be for the subject to set the right hand patch for approximate equality with its surroundings. The observations for such settings tended to fall into two groups, the one where the subject had set for equal appearance, and the other where he had resisted the temptation and had tried to set for equal luminosity.

The experiment proved a very valuable exercise in the fundamental problems of brightness sensation-stimulus relations. No further work could be undertaken, however, until 1956. This is the point at which I had a most valuable discussion with Professor S. S. Stevens at Harvard. I came away feeling that here was the key to the problem.

Method 3 — Method of Direct Estimation (S. S. Stevens' Method)

Stevens asks his subjects to estimate a sensation directly by attaching a number to the sensation. For example, in judgments of loudness, a loud tone might be given the number 100, a still louder tone 150. Consequently he avoids all the objections to the indirect methods of the Fechner school.

Stevens has described his method in detail in several publications (1955, 1956). The results which he has obtained, both published and unpublished, are undoubtedly impressive. The mechanism by which people judge a sensation and assign a number to it is not understood, and they themselves seem to have no confidence in it, yet nevertheless the numbers which they assign to the sensations plot well with the stimuli. Whether the numbers bear any fundamental relation to the sensations they purport to describe is, of course, a matter for examination. Nevertheless, I felt the method to be one worthy of study, and accordingly, immediately after my talk with Stevens, while I was still in America, I airmailed back to my laboratory a request to perform an experiment to make a set of determinations under conditions similar to those of Stevens' studies. The experiment was described in detail in my letter, but the purpose of it was not, and the experimenter had no knowledge himself of the background to the study. He therefore had no prejudices or preconceived hypotheses which could have influenced him, and through him, the subjects he employed.

The subjects were to be presented with ten luminances in random order, covering a range of 4×10^5 in luminance. A 2° field in a dark surround was employed. They were asked to put a number on the magnitude of brightness sensation. The

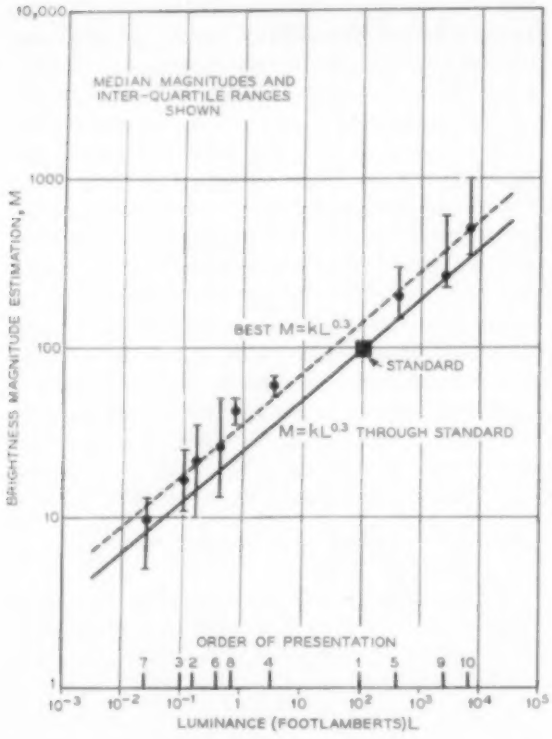


Figure 5. Estimates of brightness magnitude of small source (2° square) related to physical luminance stimulus. 10 observers. Reference standard set at 100 footlamberts and called 100.

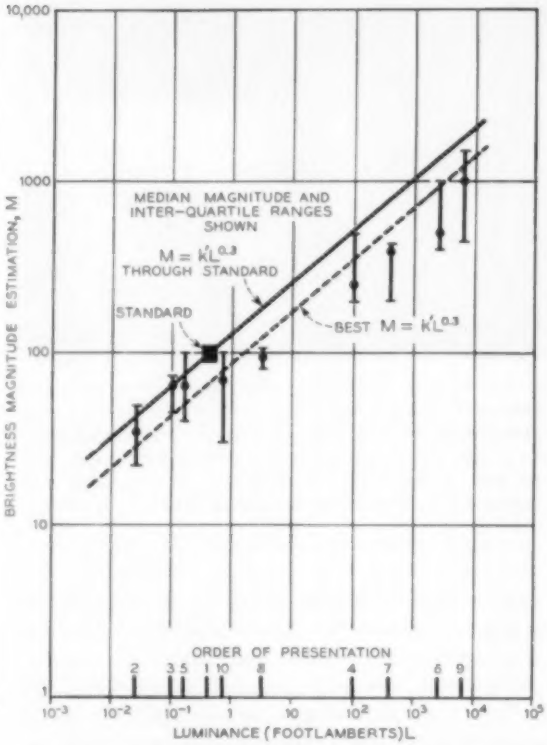


Figure 6. Estimates of brightness magnitude of small source (2° square) related to physical luminance stimulus. 11 observers. Reference standard set at 0.4 footlambert and called 100.

subjects all complained of the difficulty, in some cases of the imbecility of the experiment, exactly as had Stevens' subjects at their first attempts. They were, however, prevailed upon to complete the task, eleven observers in all making two sets of judgments. The subjects were given a standard, in the first series a luminance of 100 footlamberts was assigned to the number 100 by the experimenter, and in the second series the number 100 was assigned to a luminance of 0.4 footlambert. This setting of a standard was a decision of the experimenter himself. I had not asked for a standard, and did not want one, but he, and the colleagues with whom he discussed the experiment, could not conceive of doing the experiment without a standard. He, as well as the subject, could not muster enough confidence in "direct judgment" to following my instructions to the limit.

The results of these two determinations are shown in Figs. 5 and 6. It will be seen that the relation between the logarithm of the stimulus (luminance) and the logarithm of the brightness magnitude is an approximate straight line. I have fitted the relation $M = kL^{0.3}$ to the points. This is the relation which Stevens and his colleagues have found between magnitude of sensation (M) and physical stimulus. The fit is none too bad, but it is not perfect.

These results convinced me that a method of direct estimation offered an alternative for determining a scale of subjective brightness. It was a direct method and one which corresponded closely with the way in which the scale would be used in practice. It avoided the various half-way stages of the other methods — the doubtful Fechner integration of Abribat's method, the unnatural binocular matching of Pitt's determinations, the translation from contrast judgment to apparent brightness scale of my own pre-war determinations, and the tortuous stages of the fractionation and multiplication methods. It was impressive too, that the long-distance experiment with naive subjects and an unbiased experimenter answered some of Stevens' critics, who appeared to suggest that his subjects could only make consistent judgments after long training by a dominant personality who willed them to give the "right answers." My subjects had certainly not been under any such influence.

It is easy to understand the doubts of the critics, because the nature of the experiment is not one to inspire confidence in anyone with a conventional scientific training. It is as well to remember, however, that such doubts were not always entertained. The ancient world often had no means, other than subjective estimates, of expressing the magnitude of many entities which can now be determined by precise measurement, and they have often been shown to have been remarkably accurate in these judgments. Long before photometers existed, Hipparchus deduced a scale of stellar magnitudes, grading visible stars into six groups, the brightest of the first magnitude, and the faintest of the sixth. During the following centuries, this scale was refined, notably by Tycho Brahe and later by Argelander and his co-observers, careful and painstaking observation enabling every star visible to the naked eye, and many telescopic stars, to be assigned a magnitude, often to two significant figures. When eventually accurate photometers became available, which permitted a precise check to be made on these subjective assessments, it was found that they were remarkably consistent, and that a precise mathematical relation between observed magnitude and measured luminous intensity could be formulated.

The mystery still remains, however, why the numbers 1 to 6, and not 1 to 10, or 1 to 100 were used for the stellar magnitude scale, and this doubt applies to our present set of brightness judgments. What have people in their minds when they say that a patch has a brightness of "25," that is, not 25 units, but just "25"? What do they mean when they say that one noise is "twice" as loud as another? What exactly is "twiceness" in this context?

We simply do not know, and as engineers we do better to leave the inquiry to our extra-professional activities (that is to say, I feel that we should pursue it, but as philosophers, not as engineers). We should, however, recall that non-scientific people even nowadays, and the ancient world in general, have and had no difficulty in expressing the magnitude of intangible things. They will tell you confidently how big the moon appears to them. Down on the horizon it is as big as one of your cantaloupe melons — in the English countryside the traditional saying is that the moon is as big as a cheese. Up, in the sky it is as big as an orange. Lucretius asserted that both the sun and the moon were in fact actually no bigger and no less than they appeared to our senses to be. "Nec nimio solis maior rota nec minor ardor esse potest, nostris quam sensibus esse videtur. . . . lunaque . . . nilo fertur maiore figura quam, nostris oculis qua cernimus, esse videtur" and then used this assessment as the basis for a discussion of how the sun is able to provide such an immense amount of heat and light from such a small area.

We have, of course, to distinguish between assessments based on comparison, which is what the English countryman makes when he says that the moon is as big as a cheese and assessment expressed in absolute terms, which is what Hipparchus made and what our observers have made. As far as I can tell, however, the processes of thought seem to be the same. Certainly the more highly trained in measurement a subject is, the less confidently can he made these judgments — the best subjects are intelligent but unscientific. One observer was unable to make independent judgments — she had spent all her working life making photometric measurements in lighting installations, and her assessments, unknown to her, followed almost exactly the photometric values — she had, in fact, a scale of "absolute luminance," similar to the scale of "absolute pitch" possessed by some musical people.

On my return from the U.S.A. in May 1956, I set about an intensive program of brightness determination using the direct judgment technique, in order to study the effect of adaptation on apparent brightness. The first stage was to repeat the experiment just described, substituting for the 2° field a large surround luminance covering the whole of the field of view. Seven luminances, covering a range of 6 cycles (100,000-1) were presented in random order, and judgments made as before. These judgments were made without an initial standard.

A 2° aperture was next opened in the center of this field. The luminance of this aperture could be adjusted independently of the luminance of the large surround field. The surround field was set to a given constant value, and the subject was presented, in random order, with a series of different luminances of the 2° patch, to which he assigned numbers for the sensation magnitude. I started by giving him as a standard a number for the adaptation surround derived from the mean plot of the judgments made on the surround alone, but soon abandoned this procedure as it appeared only to confuse him or raise doubts in his mind. The method of free choice proved preferable.

Similar series of judgments were made with the surround luminance at various values from 0.04 footlamberts to 450 footlamberts.

A preliminary set of judgments obtained by three observers proved that the method could give a consistent set of data. Three other observers then made judgments. Their absolute magnitudes differed widely (*i.e.* one observer would assign, for

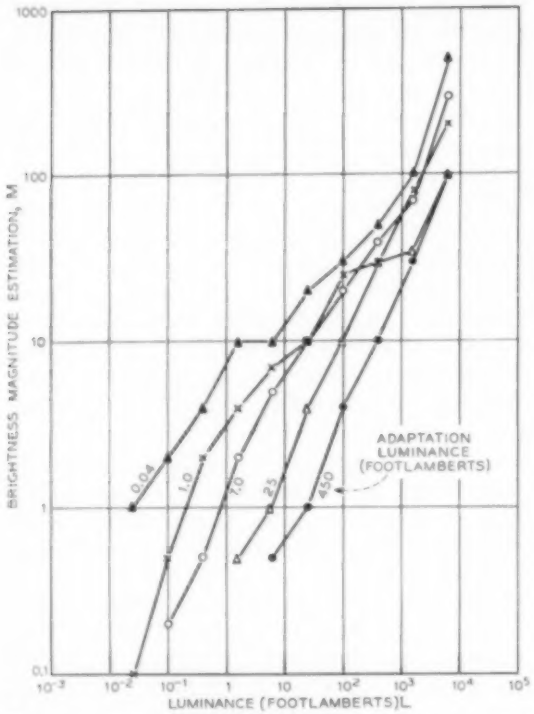


Figure 7. Estimates of brightness magnitude of small source (2° square) in large adapting field, related to physical luminance stimuli presented in random order. One observer.

example, the number 100 to the luminance to which the other assigned 3), but if their determinations were averaged, a consistent plot was obtained which could be compared with other data.

The remarks made by the subjects during the course of the experiment are of interest. Low or high brightnesses could be judged most easily, intermediate values offered the greatest difficulty. This was confirmed by the uncertainty of the plots in these regions.

Data for the highest adaptation levels plotted most consistently. A typical set of observations is given in Fig. 7. All data were faired and compared with the pre-war "contrast-scaling" data, dotted on the same scale (Fig. 8). (Refer also to Fig. 10.)

(1) The slopes of the M/L curves were shown to depend on the adaptation level, the higher the adaptation level, the steeper the slope.

(2) At low adaptations the slope approaches the relation

$$M = kL^{0.3}$$

which had previously been found for a dark surround.

(3) At high adaptation levels the slope approaches

$$M = kL^{1.0}$$

i.e. at high levels apparent brightness and luminance march in step. This is true both for the direct judgment data and the contrast-scaling data.

(4) The adaptation levels themselves from the various curves could be said to fall approximately on a line

$$M = kL^{0.3}$$

if we were trying to prove a case, but the departures from this regression are different for the direct judgment data than for the contrast-scaling data.

(5) The contrast-scaling data assign approximately the same sensation magnitudes to low luminances as do the direct judgment data, but differ widely in the high luminances. The luminosity photometer experiment, it will be recalled, recorded discrepancies with the contrast-scaling data in these regions.

At this stage a decision had to be made whether to continue the work with a very limited number of subjects, or wait until a full research program could be undertaken. The temptation to go a little further could not be resisted, even though we knew that the data we obtained could be of little more permanent value. The subjects by now were gain-

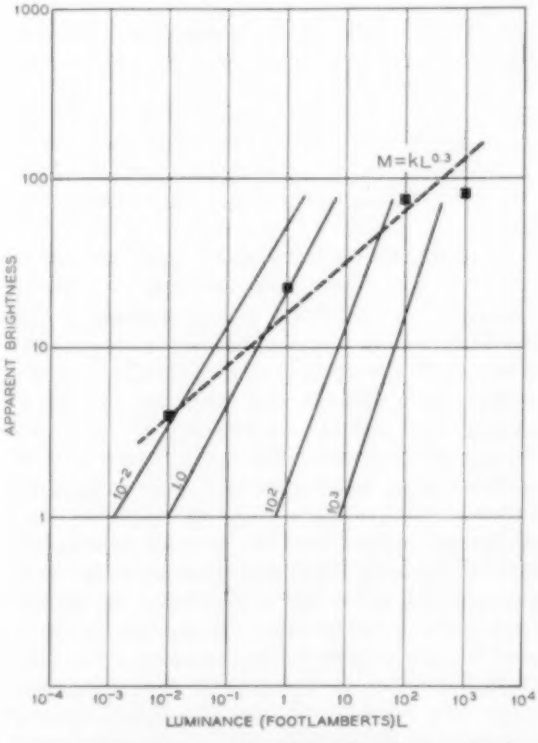


Figure 8. The data of Fig. 1 re-plotted on a log/log scale (data for four adaptation levels only).

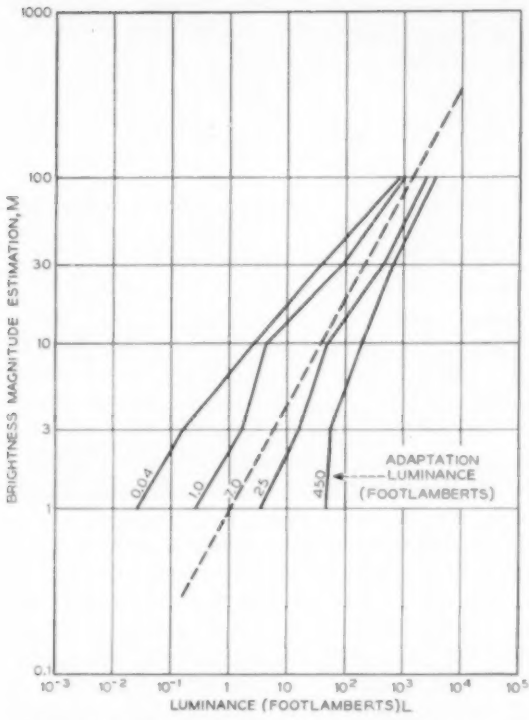


Figure 9. Settings of luminance of 2° source to give constant apparent brightness when luminance is varied. Source pre-set to each of five previously judged levels of apparent brightness at adaptation luminance of 7.0 footlamberts.

ing confidence in their judgments and were less inclined to protest.

One variant was introduced. A series of "cross section" checks of the data was made, in which the subject was asked to remember the apparent brightness of the patch in another surround to this remembered magnitude. This was done at five levels of brightness magnitude, at these levels of adaptation (0.04, 7.0, and 750 ft-L) for datum; data for one observer are shown on Fig. 9. Two observers made these cross-check observations.

Finally a grand average of all the observations was made, for two subjects. The observations of all the subjects could have been included, but were not because they were incomplete and their inclusion would have introduced weighting problems. This average is shown in Fig. 10. The curves as drawn attempt to take into account the fact that at any given adaptation level, there will be a range of luminance which appears "black" to the observer. The determination of this "subjective black" is one which has proved a stumbling block to previous investigators, *e.g.* Pitt (1939), and we decided to avoid the problem at this stage. Since

TABLE I — Percentage of Occasions on which a Given Luminance of a 2° Source Appeared Black under Different Adaptation Luminance Conditions.

SOURCE LUMINANCE (ft-L)	ADAPTATION LUMINANCE (ft-L)				
	0.04	1.0	7.0	25	450
	PERCENTAGE OF OCCASIONS				
0.025	0	80	100	100	100
0.1	0	0	83	100	100
0.4	0	0	0	40	100
1.6	0	0	0	0	80
6.4	0	0	0	0	17
25.6	0	0	0	0	0

the luminances of the 2° field which were presented to the observer were in stages of 4:1, it was not easy to deduce from the judgments the value of the maximum luminance which would just appear black. Instead, a table was drawn up as shown, listing the number of occasions on which any given luminance appeared black in the course of the judgments. From this, the highest value which would appear black on 100 per cent of all occasions was estimated, and this was taken as the asymptote for the relevant apparent brightness curve on Fig. 10.

It is a subject of philosophical argument as to whether this value of luminance should be assigned the sensation magnitude 0. "Blackness" is, accord-

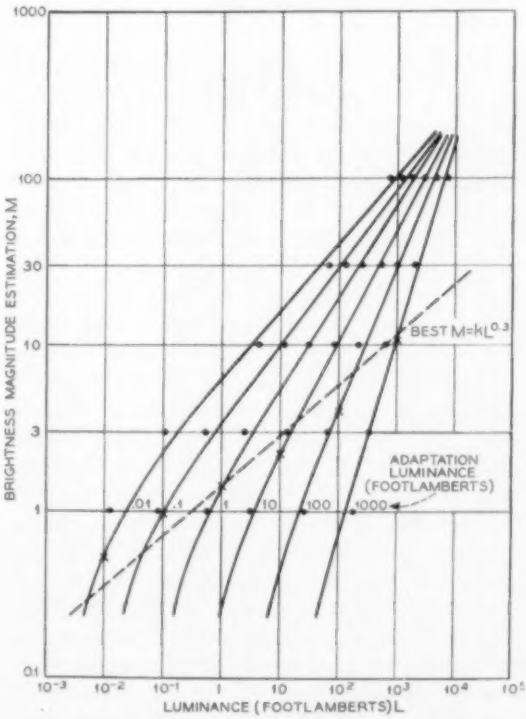


Figure 10. Faired data of all brightness magnitude estimations for two observers. 2° source in large adapting field.

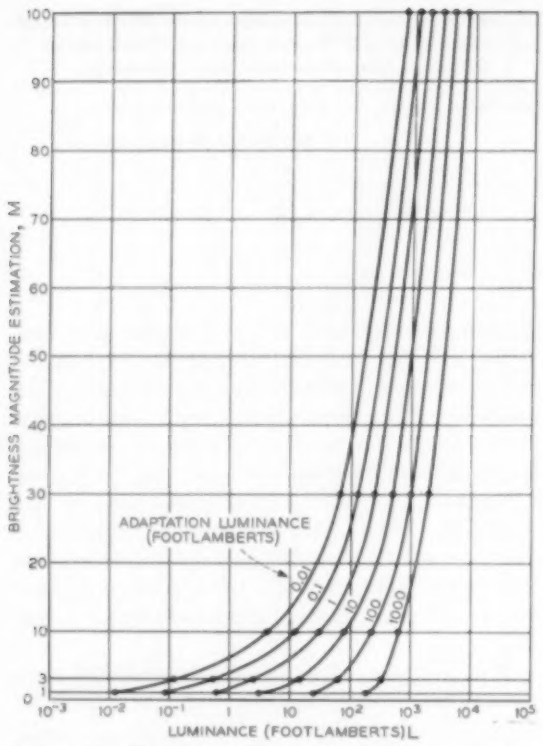


Figure 11. The data of Fig. 10 on a linear scale of brightness magnitude, logarithmic scale of physical luminance.

ing to many, including Hering, a positive sensation, not a zero sensation. Equally the nature of the sensation-stimulus curve in these lower regions is speculative. Some observers did use fractional numbers for their estimates, and one observer never gave "black" as a response at all, using minute fractions instead. He explained his reason for this in the words "I knew there must be something there even though I couldn't see it, so I guessed a small fraction. The whole thing was a guess anyway." When it was explained that on occasions there had in fact been no stimulus presented, the subject shrugged indulgently. Stevens (1955) quotes Robinson (1953) as suggesting "when intensity crosses the threshold, loudness comes on with a jump." Nothing like this happens in brightness. If the 2° patch is black, and its luminance is slowly raised, eventually, as the threshold is passed, a faint glimmer is seen, but there is no "coming on with a jump." At the moment, therefore, it is best to leave the argument until further basic studies of near-threshold sensations can be undertaken.

The data of Fig. 10, or the same data on a linear/log plot (Fig. 11) would, if they had been based on sufficient observations from a sufficient number of subjects, serve as the basis for a *standard scale of apparent brightness*. Such scales have been proposed before (*e.g.* the brill scale of Wright (1940), the brill scale of Hanes, Michel, and Helson (1953, 1954) and others). The present scale is more comprehensive than these in that it takes adaptation fully into account, a matter of importance to the lighting engineer. It is in the same form as the original "contrast-ladder" scale, but, being based on direct judgments with free choice, it does not suffer from the criticism that apparent brightness, one type of sensation, has been reached through contrast, another type of sensation. But quite apart from the fact that it is based on the judgments of too few observers at the moment, it is incomplete, in that it applies only to judgments on a 2° patch in a large field. We need to know how the size of the test patch governs the judgment of brightness, and whether as the work of Hanes (1951) suggests, in a comprehensive scale, separate relations are necessary for different areas of stimulus just as they are for different adaptations. We also need to assess the effect of simultaneous contrast, for example, the effect that the presence of the 2° patch has on the judgment of the brightness of the surround. The work is therefore not anywhere near a stage of finality, and it would certainly not be wise to use the data of Fig. 10 as a working scale for any conditions other than those of the experiment. But we have made a step forward.

Two features of the results which have already been pointed out are perhaps worth special attention, features which are common to both the direct-judgment (Fig. 10) and the contrast-scaling (Fig. 8) data. The first is that, at high luminances, the sensation of brightness magnitude bears almost a linear relation to the luminance. This does not mean that a luminance of (say) 30 footlamberts will be assigned the numeral $M = 30$, but it does mean that if the subject judges 30 footlamberts as $M = 10$, he will judge 300 footlamberts as $M = 100$, *i.e.* ten times as great, in the same ratio as the luminances. The need for a subjective scale at high levels of luminance is therefore limited, since the luminance scale itself will accord well with the subject's judgment of brightness magnitude, within the obvious limitations. This does not, of course, mean that the research is wasted effort. Without the investigation we would not know the special properties of the luminance scale, whereas now we can be fairly certain that if the lighting engineer is asked by the layman client to make, say, a ceiling "twice as bright as before," he will achieve the aim by making the luminance twice as great.

The other feature of the results, of more impor-

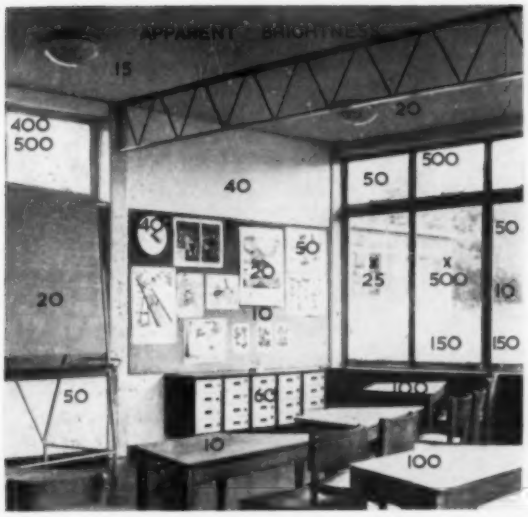


Figure 12. Photographs of the same room as Fig. 1, by daylight, with values of apparent brightness (estimated magnitude).

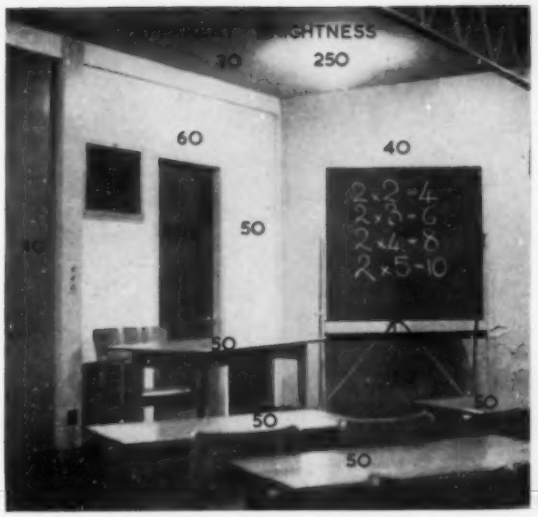


Figure 13. Photograph of the same room as Fig. 2, by artificial light, with values of apparent brightness (estimated magnitude).

tance to the psychologist than to the lighting engineer, is the way in which the relation $M = kL^{0.3}$ crops up. The similarity between the judgments of brightness sensation in a dark surround and loudness sensation in an anechoic room, when each is related to the relevant energy stimulus, may be more than coincidental. If it is real, it follows that the assignment of a numerical magnitude to a sensation is a basic mental process taking place in the higher centers of the brain, and that there is some essential similarity between the visual and aural mechanisms which convert energy into sensation.

We now have our scale of apparent brightness, and we can now examine our school classrooms again. (Figs. 12 and 13.) Instead of the luminance values that we had before, we can work on the apparent brightness values. It is seen that the walls are now given apparent brightness of the order of 50 on the scale, and in daylight they are given a value of about 40 which is just slightly less. If you compare the apparent brightnesses in detail for the daylight and the artificial light scene, you will see that things which look about equally bright to you are assigned equal numbers on the apparent brightness scale. We have in fact a scale now which really accords with What We See.

Conclusion

It is not the purpose of this paper to detail the uses of an apparent brightness scale. That must await another occasion. This paper is clearly the beginning, not the end of a story. It shows, I think, that a useful engineering scale of apparent brightness can be derived by various methods, including direct estimation. The effects of adaptation can be allowed for. Much more work is necessary before a final scale can be put forward.

Nevertheless I feel that we ought to look forward to this step and I would like the C.I.E. to turn its attention to the problem. The acoustic engineers are well ahead of us here. There is already an American Standard loudness scale and talk of an international standard. If the science of acoustics can do this, with the enormous discrepancies that have occurred between the different determinations, we should be able to do at least as well.

I would put forward as a basis for discussion a suggestion that the *apparent brightness magnitude should be expressed in units which are numerically equal to luminance units when the adaptation luminance is 1000 footlamberts.* When the adaptation luminance is other than 1000 footlamberts, the brightness magnitude expressed in apparent brightness units should be determined from an internationally agreed set of data which might be similar to that of Fig. 10 but which might also include an allowance for the area of the test field and for simultaneous contrast.

Acknowledgments

The work reported in this paper covers a long period, from the time when I was working on my thesis under the late Mr. G. H. Wilson, to the postwar period when my colleagues, Dr. Gilbert in 1949-50, and Mr. Longmore in 1956, did the experimental work for me. My acknowledgments to them

and to all the subjects who consented to make observations on experiments which seemed futile to them is gratefully made. My special gratitude is due to Professor S. S. Stevens, whose own studies and enthusiasm for them set me about the latest stage of the work, which I greatly hope will not be the last.

I acknowledge also the permission I have received from the Director of Building Research to publish this paper; the general program of lighting research to which the work belongs is part of the program of the Building Research Board of the Department of Scientific and Industrial Research of the United Kingdom.

References

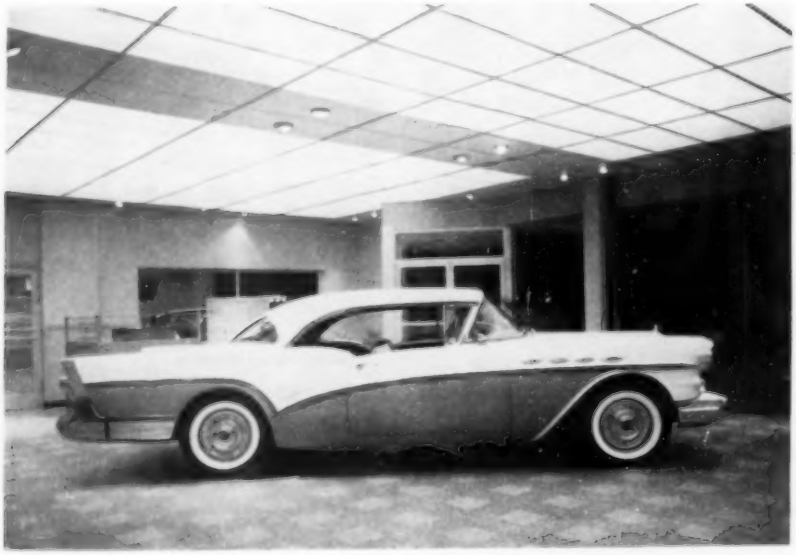
Abribat, M. Sciences et Industries Photographiques, 6, (Serie 2) 177, (1935).
Bekesy, G. von. Acta. Oto-Laryng. (Stockholm) 35, 411 (1947).
Bickerdike, J. B., Allen, W. A., *Proc. C.I.E.*, Stockholm, 2, Paper R., (1951).
Craik, K. J. W., *J. Physiol.* 92, 406 (1938).
Craik, K. J. W. *Proc. Roy. Soc.* S 128, 232 (1940).
Hanes, R. M. *J. Exp. Psychol.* 39, 719 (1949).
Hanes, R. M. *J. Opt. Soc. Amer.* 41, 28 (1951).
Hess, C., and Pretori, H., *Archiv. fur Ophthalmologie*, 40, 1 (1894).
Hopkinson, R. G., *Trans., I.E.S.* (London) 4, 13, (1939) (discussion on paper by Wright, W. D.).
Hopkinson, R. G., Stevens, W. R., and Waldram, J. M., *Trans. I.E.S.* (London) 6, 37 (1941).
Hopkinson, R. G., *J. I. E. E.*, 93 (Part III A), 795 (1946)
Hopkinson, R. G., Council of Industrial Design, London. *Proceedings, Conference on Lighting and Colour* (1948).
Hopkinson, R. G., *Light and Lighting*, 44, 10. (1951).
Hunt, R. G. W., *J. Phot. Sci.*, 1, 149 (1953).
Merkel, J., Philos. Studien (Wundt) 4, 541 (1888) and 5, 245, and 5, 499, (1889).
Michels, W. C., and Helson, H., *Am. J. Psychol.*, 39, 719, (1949).
Oldfeld, R. C., *Nature*, 164, 581 (1949).
Pitt, F. H. G., *Proc. Phys. Soc.*, 51, 810 (1939).
Robinson, D. W., *Acustica*, 3, 344, (1953).
Stevens, S. S., *Amer. J. Psychol.*, 69, 1, (1956).
Stevens, S. S., *J. Acoust. Soc. Amer.*, 27, 815, (1955).
Stevens, W. R., and Waldram, J. M., *Trans. I.E.S.* (London) Convention Proceedings, (1946).
Waldram, J. M., *Trans. I.E.S.* (London), 19, 55, (1941).
Wright, W. D., *Trans. I.E.S.* (London), 41, 1 (1939).

Display Lighting for New Cars

To display the shiny new automobiles to best advantage, a combination of fluorescent and incandescent has been used in the showroom of Adcock Buick Co., St. Petersburg, Fla. An aluminum louverall ceiling is mounted 11 feet from the floor, with single-lamp 8-foot channels of slimlines mounted on two-foot centers in the white plenum. Average level from this system is 80 ft-c on the horizontal surfaces and 30 ft-c on the vertical. Supplementary lighting over the cars, from PAR-38 floods, is 120 ft-c. These gimbal ring fixtures are spaced around the sales room to bring out the sparkle of the chrome.

Upper walls are pink, 60% RF; lower walls of natural wood, 60% RF; floor is gray, 40% RF. The area is 38½ feet by 29¾ feet.

Installation designed by David A. Whitson, Florida Power Corp., Clearwater, Fla., and R. Y. Fernandez, Madeira Beach, Fla. Lighting installed by G. S. Grant, Inc., St. Petersburg, Fla.



INSTALLATION IN MAYFIELD HEIGHTS, OHIO.

Wall Lighting from a Wall-to-Wall Fluorescent Bracket

LIGHTING OBJECTIVE: To provide general lighting from an element designed to blend architecturally with the structure in a studio-ceilinged room and at the same time provide local lighting for an extra-long custom-made sofa.

GENERAL INFORMATION: This living-dining room is 16 feet by 38 feet and has a multiple-sloped ceiling which is 14 feet 6 inches from the floor at its peak and 7 feet 6 inches at the lowest point.

All the surfaces in the room are unusually light; white ceiling about 80 per cent reflectance and warm beige walls about 70 per cent. The carpet is a very close match to the walls, and the sofa and large cocktail table top just a few shades deeper (about 50 and 60 per cent respectively). Color accents are provided by occasional chairs and cushions of French blue and bittersweet. There is a 10-foot wide floor-to-ceiling fieldstone fireplace on the wall opposite the sofa (not shown) and a 15-foot window draped with lightweight fabric closely matching the walls. The two ends of this living-dining area are panelled in white oak from the floor up 8 feet to the cove.

INSTALLATION: The fluorescent bracket in this room could almost be called a cove except that it provides downward light as well as upward light. It was designed to become an integral part of the architecture of the room, and extends the full length of one side. The bottom of this element

(over)

A.I.A. File No. 31

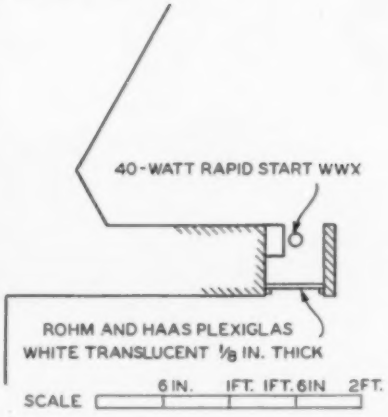


Figure 2. (left) Close-up of bottom of lighted wall bracket with section of plastic removed.

Figure 3. (above) Detail of lighted bracket.

is 7 feet 6 inches above the floor. As shown in the sketch and in the photograph taken from below, it uses a single rowof 40-watt rapid-start deluxe warm white fluorescent lamps centered 2 feet from the ceiling as it starts to slant toward the peak. The bottom of this 8-inch wide bracket is closed with translucent white plastic panels (Plexiglas, ⅛-inch thick). Since the sofa is set into the 2-foot 4-inch deep niche designed for it, the fluorescent tubes are directly over reading-task position. They supply 10 footcandles all along the sofa, while the table lamps (R40 50/150 white indirect) supply an added 35 footcandles at its ends.

Lighting opposite the sofa is provided by three 150-watt prismatic type units recessed in the 8-foot-high flat ceiling of the window area (balancing the sofa niche).

Brightneses of the areas on the sofa side of the room are as follows:

ceiling high above bracket	19 ft-L
brightest part of ceiling directly above bracket	25 ft-L
center of wall over sofa	7 ft-L
floor near center of sofa	6 ft-L
lamp shades	70 ft-L
wall above lamps	53 ft-L
plastic bottom of bracket (looking straight up)	165 ft-L

Brightnesses on the drapery wall opposite sofa run from 10 to 50 footlamberts. Only a small portion of the prismatic glass in the recessed units is visible from the sofa, so its 600-footlambert brightness is not disturbing. These units provide 30 footcandles at reading position when chairs are located directly beneath them.

The room has a feeling of great spaciousness due partly to its very high ceiling and the daytime clerestory lighting along one end and part of one side. However, it is equally airy and spacious in feeling at night. All wall and ceiling areas are closely related in brightness.

Architects: W. D. Riddle and Carl Droppers.

Lighting data submitted by W. D. Riddle, Architect, General Electric Lighting Institute, Nela Park, Cleveland, Ohio, as one solution to a lighting problem and to aid in the design of similar installations.

Published by the Committee on Publications of the Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.

Multi-Functional Suspended Ceiling

EPITOMIZING modern design for modern facilities, the new Blue Cross Building in Los Angeles contains the West's largest clear-span office area, 110 feet by 210 feet, with the plastic ceiling 18 feet above the floor. The building was designed specifically to facilitate the processing of mass data by about 300 employees of the hospital service organization. Their work includes IBM card punching and filing, writing of policies for subscribers to Blue Cross, and the usual office operation.

Because of the importance of accuracy in handling great numbers of cards and records, good, uniform lighting was a major factor in the building's design. Control of office noise was another — with 250 people all working in the main room. For the same reason, of course, adequate air distribution was also important.

These requirements have been met by a suspended ceiling of light, which also provides the additional services. Illumination is maintained in excess of 90 footcandles. Continuous rows of standard cool white slimline lamps — 682 eight-foot T12 and 124 foot-four T12 — are mounted on 36-inch centers on the structural slab. Rods from the lighting channels carry a steel channel grid which supports the corrugated Plexiglas light diffusers, the air ducts above them, and 12-inch light metal acoustical baffles hung below the diffuser line. The baffles are on 36-inch centers running the shorter way of the room. Diffuser bottoms are matt finished to avoid reflections from below; they are visible between the baffles only in the immediate foreground. The plastic wall-to-wall ceiling is maintained once each year by contract.

The building's southerly side is protected against sky glare and heat by automatic louvers which operate by solar time switch according to the sun's position.

Air from the multi-use ceiling is distributed through three rows of outlets, and return air is drawn upward into the plenum through the corrugations of the light diffusers. The plenum cavity in which air ducts are located varies from 3 feet 6 inches to 4 feet in depth. No finishing of the structural ceiling was necessary beyond painting the entire plenum white. Walls below the diffusers have 50 per cent reflectance, and the vinyl tile floor is 30 per cent (light gray). To further maintain good brightness ratios within the visual field, all furniture and desks are of light gray finish.

From data submitted by Wakefield Lighting Co., Vermilion, Ohio, and Roy H. Kreyser, Department of Water and Power, City of Los Angeles.

Discomfort Glare at Low Adaptation Levels II—Off-Axis Sources

By RUSSELL C. PUTNAM
WILLARD F. GILLMORE, JR.

VISUAL COMFORT in a street or highway lighting installation interests the lighting engineer as well as efficiency, distribution, pavement brightness, visibility, and the other factors in which he is concerned. Much has been done by various researchers in the field of visual comfort for adaptation levels typical of those encountered in indoor lighting practice but comparatively little has been done for the low adaptation levels met in street lighting work.

One of the techniques that may be applied for measuring visual comfort is the method of experimental determination of the brightness that is on the borderline between visual comfort and discomfort under different conditions. The BCD technique of Luckiesh and Guth[1,2] has been applied by Putnam and Faucett[3] to a study of light sources of visual sizes applicable to street lighting conditions when viewed on the horizontal line of sight against low brightness backgrounds. This paper reports on work that is a further step in the total problem.

There are three different criteria which have been used successfully in rating the absolute sensation produced by a single brightness source. These three criteria are the threshold of visual perception, the threshold of discomfort glare, and the threshold of intolerable brightness. Since extreme values of brightness are of no particular importance in this investigation, it is better to consider values at or near the threshold of discomfort glare.

Discomfort glare exists when brightness relationships in the field of view cause discomfort but do not necessarily interfere with seeing. Both direct and reflected discomfort glare can occur in practical situations. The glare sources used in this study are direct, of course, but the results should apply equally well to either type of glare.

Visual comfort is based on certain physiological and psychological factors which vary greatly from one individual to another and even vary in a given individual from day to day. The only method for rating the comfort of a light source, therefore, is to have a large number of observers rate the sensation, not once but preferably many times. The combination of the results of all these observers can establish a definite trend. It is this trend, rather than the individual readings, which is significant. However, the average and the range of the large group are of importance in establishing brightness limitations.

It is important to notice here the difference between subjective and objective measurement. Measurements of the quantities involved in the physical sciences are objective in nature and may in general be made as precisely as the measuring equipment will allow. Subjective measurements, on the other hand, are limited in accuracy by the relatively large differences among individuals and the more moderate variations within the individuals themselves. The exact cause of these variations is not well understood, but the effect is to limit the precision with which a quantity, such as discomfort glare, can be determined. Because of these variations, overall averages are more meaningful than single readings. In fact, in many cases averages will clearly indicate smooth trends which are more or less typical of all individuals.

The results of this investigation are based on nearly a thousand readings taken by ten observers. These were taken over a period so that usually an observer spent less than half an hour at a time taking readings. This precaution was to reduce the possibility of fatigue affecting the readings. Ten observers can only indicate the trend of the final results but the time available for this investigation was limited. It is hoped that further investigations will add more data that will be applicable to this problem.

The chief factors influencing discomfort glare are: (1) the brightness of the source, (2) the visual size of the source, (3) its relative position with respect to the line of sight, (4) the background brightness or adaptation level, and (5) the time of exposure. In this investigation only the first four factors were varied, the factor of time being fixed

A paper presented at the National Technical Conference of the Illuminating Engineering Society, September 17-21, 1956, Boston, Mass. AUTHORS: Case Institute of Technology, Cleveland, Ohio.

by the flashing sequence. The range of source sizes (ω) was from .0011 to .000001 steradian, the range of background or field brightness (F) was from 1.0 to .001 footlambert, and the range of angles (θ) above the horizontal was from 0 to 30 degrees. Source brightness (B) was the independent variable set by the observer.

A two-meter hemisphere was used to provide a uniform adaptation brightness, Fig. 1. The observer viewed a light source directly in front of him and on the line of vision (the comparison source C) while adjusting the brightness of another source (the test source T) above the comparison source to a value which he considered to give a sensation at the borderline between comfort and discomfort (BCD). Fig. 2 shows the position of the light sources on the sphere. A head rest was used to keep the observer's head in the correct position. The shielded lamp which illuminated the background is also shown in Fig. 2.

The test and comparison sources used in this experiment were exposed to the observer's view in a systematic flashing sequence. The flashing cycle was twenty seconds in duration and consisted of alternate exposure of test and comparison sources. The first three flashes were one second each and were separated by off periods of one second. This was followed by a five-second off period. The second half of the twenty-second period was identical to the first half except, of course, the order of exposure of the two sources was interchanged. In the first part of the experiment, when only one brightness source was used, it was made to flash on during each of the one-second "on" periods.

Figure 1. The observer looked into a large hemisphere which provided a uniform adaptation brightness. The position of the head-rest, the control for source brightness, and the shielded lamp which illuminates the background are also shown.

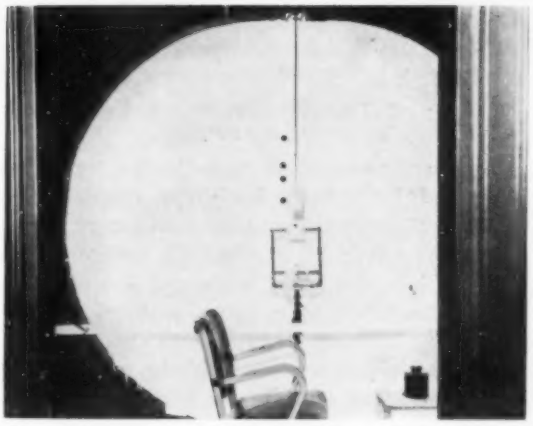


Figure 2. A front view showing the four positions of the test source at 7½°, 15°, 20° and 30° above the horizontal line of sight.

This flashing sequence was selected for two reasons. First, it is easier for an observer to evaluate a sensation of brightness from a short exposure than it is to judge the same sensation when prolonged. Second, the momentary exposure keeps the observer's adaptation at a level more nearly equal to that of the background brightness. The flashing sequence is the same as that used in the previous discomfort glare studies.

Instead of allowing the light sources to go completely out during the off periods, they were held at a low standby voltage which approximately matched the background. This served two purposes. It prevented the observer from seeing a black spot, and it kept the filaments warm so that they responded faster on the next pulse of current.

Each observer, upon starting the series of tests, was asked to set a source subtending a solid angle of .0001 steradian at a brightness which he considered to be the borderline between comfort and discomfort. The source was on the direct horizontal line of vision and the background brightness was set at .01 footlambert. Five such readings were taken the first day, and the observer was asked to return on a subsequent day to take five more readings. These readings served to familiarize the observers with making borderline judgments necessary to BCD determinations, to key this group of

observers to that of the previous investigation,[4] and to determine their relationship to a normal distribution. While ten observers were a small number, a plot of their readings indicated a good approach to a log-normal distribution.

In the next part of the investigation the source sizes and background brightness remained the same: .0001 steradian and .01 footlambert respectively. As before, the observer was told to look at the source on the direct horizontal line of vision (*C*), but as he did so, he was to adjust the brightness of the test source (*T*), located above the comparison source, to a value which he considered to give a sensation equal to the comparison source. The comparison source at the center was maintained at 315 footlamberts by the experimenter. This value could have been any arbitrary brightness, but the value of 315 footlamberts was selected because it represented approximately the average threshold of discomfort glare selected previously in a study similar to part I of this experiment.[4] Each observer took six readings on the test source on different days at each of the following angles above the horizontal: 7½°, 15°, 20°, and 30°. 30° was taken as the maximum angle based on the average angle of a driver's horizontal line of sight and the top of a car's windshield.

The variation of BCD brightness as expressed as the geometric mean of the readings of the ten observers for the various vertical angles is given in Table I and is shown by the solid curve in Fig. 3. Experience and the results of previous investigations at other adaptation levels[1,2] confirm these findings that the higher the light source is above the line of vision the higher the brightness of the source can be before it is uncomfortable. Of the ten observers, the readings of seven followed the theory closely while the other three found a slight decrease in BCD brightness for the angles above the line of vision. The upper line in Fig. 3 shows how the geometric mean of the seven observers varied linearly with the vertical angle.

The size of the test source was then varied while the angle above the horizontal remained fixed at

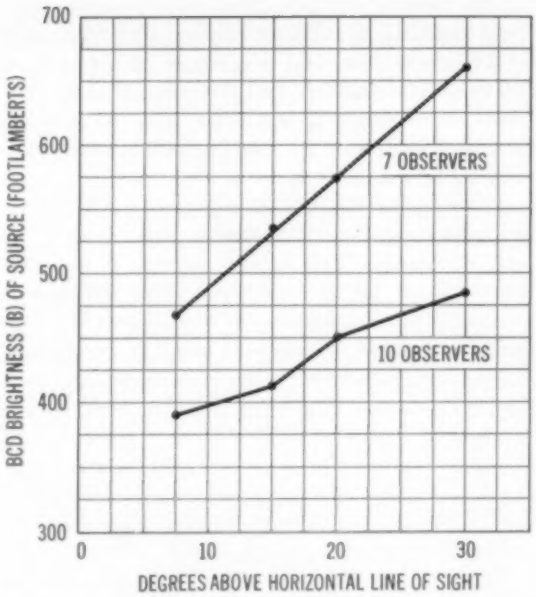


Figure 3. The relationship between the BCD brightness (*B*) of a source, subtending a solid angle at .0001 steradian against a surrounding field brightness of .01 footlambert, and the angle above the horizontal line of sight.

20°. The background brightness was maintained at .01 footlambert and the comparison source of .0001 steradian was again set at 315 footlamberts. The observer was asked to adjust the test source (*T*) until it gave the same sensation of visual comfort or discomfort as the comparison source (*C*) at which the observer was looking. Six readings were taken by each observer on different days at each of the following solid angle sizes of the test source: .0011, .0001, .00001, and .000001 steradian. Table II gives the geometric mean values of the readings of the ten observers for the four sizes of test sources investigated, and these are shown graphically by Fig. 4. The dashed line indicates the slope of Ricco's Law,[5] which states that for very small light sources the sensation produced by the product of the area of the source and its brightness is a constant. This slope is very close to that of a straight

TABLE I — BCD Brightness Values for Angles above the Horizontal Line of Sight.
(Expressed as the geometric mean of readings by ten observers for a source size of .0001 steradian and a background brightness of .01 footlambert.)

Degrees Above Horizontal Line of Sight	BCD Brightness
7.5 degrees	392
15 "	416
20 "	451
30 "	485

TABLE II — The Variation of BCD Brightness with Size of Sources.
(The geometric mean of readings by ten observers for 20° above the line of vision and a background brightness of .01 footlambert.)

Visual Size of Test	BCD Brightness
.000001 Steradian	121,500
.00001 "	16,730
.0001 "	451
.0011 "	132

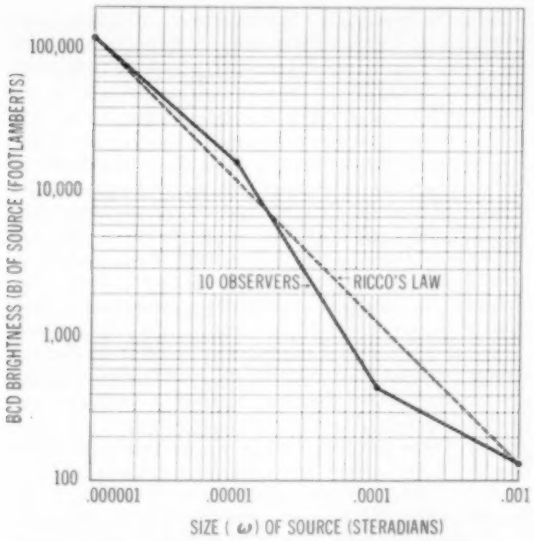


Figure 4. The relationship between the BCD brightness *(B)* of a source, located at 20° above the horizontal line of vision with a background brightness of .01 footlambert, and the size (ω) of the source as expressed in steradians.

line drawn between the readings of the observers (Fig. 4).

The complete investigation from which the data for this paper was taken[6] gives the statistical mathematics involved in determining the closeness of the readings of the observers to a normal distribution and the range of probable errors, as well as some of the psychological and physiological aspects of the study. Further investigations are now in progress on discomfort glare from multiple sources which will give more information on the problem. When a sufficiently large amount of data is available, it should be possible to generalize the results to include light sources of arbitrary shape, size, position and brightness distribution. This would go far to eliminate the uncertainty in the prediction of comfort in lighting designs for streets and highways.

Acknowledgements

The authors wish to thank Dr. S. K. Guth, whose advice has been very helpful, and the following people who made this investigation possible by serving as observers:

Miss M. L. Bissell
Mr. H. J. Braschwitz
Mr. R. J. Evanick
Miss D. E. Gates
Mr. R. B. Gillmore
Miss R. A. Hudak
Miss J. F. Kriege
Mr. A. E. Misek
Mr. R. C. Putnam
Mr. E. W. Stage
Mrs. E. W. Stage
Mr. M. D. Walz

References

1. Luckiesh, M., and Guth, S. K.: "Brightness in Visual Field at Borderline between Comfort and Discomfort," ILLUMINATING ENGINEERING, Vol. XLIV, No. 11, p. 650 (November 1949).

2. Guth, S. K.: "Comfortable Brightness Relationships for Critical and Casual Seeing," ILLUMINATING ENGINEERING, Vol. XLVI, No. 2, p. 65 (February 1951).

3. Putnam, R. C., and Faucett, R. E.: "The Threshold of Discomfort Glare at Low Adaptation Levels," ILLUMINATING ENGINEERING, Vol. XLVI, No. 10, p. 505 (October 1951).

4. Faucett, R. E.: "The Threshold of Discomfort Glare at Low Adaptation Levels," Master's Thesis, Case Institute of Technology, 1951.

5. Bartley, S. Howard: *The Psychophysiology of Vision*, in *Handbook of Experimental Psychology*, edited by S. S. Stevens, John Wiley and Sons, 1951.

6. Gillmore, W. F., Jr.: "Glare Above the Direct Line of Vision at Low Adaptation Levels," Master's Thesis, Case Institute of Technology, 1955.

DISCUSSION

ROBERT E. FAUCETT:* I believe one of the highest compliments that can be given a man is to have his former college professor conduct a basic research project based upon work previously done by that man. I am very much complimented by Professor Putnam and wish to extend my sincere appreciation to him and Mr. Gillmore as well as all others who have had a part in giving me this opportunity for discussion.

One criticism which I have received and would like to pass on at this time is the use of the term "steradians." This term, I have found, is one which is generally unfamiliar with most of us and is, therefore, difficult to visualize. For those of you who are interested in visualizing these small sizes, the 0.0001 steradians size source as used in Fig. 3 of the authors' paper is the same visual subtense obtained by viewing a 0.451-inch diameter circle from a distance of one meter. Or, another way of visualizing these small solid angles is to realize that one square degree is equivalent to 0.000325 steradians. I have had some difficulty in locating a mathematics text with reference to the term "steradians"; however, it is easily calculated by dividing the area of subtense by the square of the viewing distance.

The authors chose the surround brightness of 0.01 footlambert in determining the bulk of the BCD data. It is realized that the time available to complete this work was insufficient to determine data for all possible conditions; however, there exists a strong feeling that these data would be much nearer to being applied practically if additional data were available for adaptation brightnesses above and below the figure of 0.01 footlambert. Another missing link in the whole consideration is that of actual adaptation level. What factors effect the adaptation level? Some of these factors would, of course, be psychophysical characteristics of the individual as well as the effective incident footcandles on the eye. What are the residual effects upon adaptation due to variations in incident footcandles on the eye as one travels past the sources? Of academic interest, is there possible some wavelength in the visible spectrum that produces a considerably lesser BCD without any reduction in visibility?

The authors state that 30 degrees above the line of sight was the maximum angle of displacement considered as "based on the average angle of a driver's horizontal line of sight and the top of the car's windshield." It has been pointed out[1] that this average angle is not 30 but 14 de-

*General Electric Co., Outdoor Lighting Department, Hendersonville, N. C.

grees. Therefore, perhaps future studies can be safely kept to angles of 20 degrees and less above the line of sight. Also, perhaps broader applications of these data should be kept in mind — for example, taxiing aircraft. After the plane has landed it must proceed to the parking apron. Additional considerations of this type may provide researchers with justification for studies extending below the line of sight as well as above.

Certain extrapolations can be made from data contained in the paper under discussion and previous studies. I recently made some of these extrapolations to estimate what the BCD values would be for various size sources against surround brightnesses above and below 0.01 footlambert. Later Professor Putnam informed me that these data have already been experimentally determined, but too late to be included in this paper. I shall, therefore, not divulge my extrapolations but would rather look forward to Professor Putnam's next paper reporting these data along with the next phase of the overall research project.

1. Rex, Charles H.: "Improved Seeing Efficiency with Roadway Lighting." *Traffic Engineering*, August 1956, pp. 476-484.

SYLVESTER K. GUTH:* This progress report indicates that Professor Putnam and his associates are moving forward in their program to provide a fundamental basis for the development of a discomfort rating method for street and highway lighting. Studies such as these have long been needed to fill some of the many gaps in our knowledge of the effects of light and lighting upon people. The authors are to be complimented for continuing this coordinated series of investigations.

The paper brings to mind two very important points — extrapolation and subjective differences. These are recognized by the authors, but they may be worth re-emphasizing.

The data obtained in these experiments illustrate that low field brightnesses result in somewhat different relationships among the basic factors than do the higher field brightnesses encountered in interior lighting situations. Only too often those who want to use available data find that their particular conditions fall outside the range of the variables and therefore resort to unjustifiable extrapolations. Their desire to make immediate practical use of the data is commendable but the extensions often result in unwarranted conclusions. However, these data, and others to come, should ultimately help us to map out the fundamental relationships for a wide range of conditions and thus minimize any need for extrapolation.

The influence of subjective differences and the need for representative observers are illustrated by the data for sources displaced various angles above the line of vision. People differ in their sensitivity to a stimulus. Therefore, it is desirable to have available a large number of observers, or a smaller number who are typical of a larger group. Unfortunately, this is not always possible and it becomes necessary to analyze and evaluate the data as the authors have done. Data obtained from a limited number of observers generally will establish basic relationships but a larger group is required in order to determine the significance of absolute values of the variables.

These comments are intended as a *caveat emptor* to possible users of the data. They will have to exercise caution until the more complete information is available from experiments now in progress.

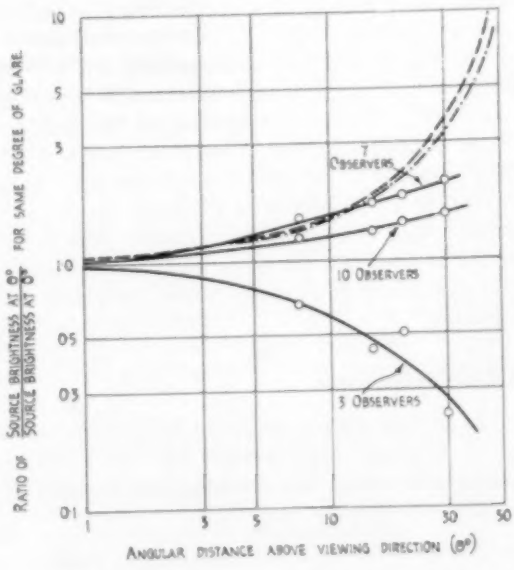
*General Electric Co., Cleveland, Ohio.

R. G. HOPKINSON and P. PETHERBRIDGE:* This latest contribution from Professor Putnam's laboratory is a welcome addition to knowledge of the effect of source position on discomfort glare. The results show a marked but not unexpected difference between the glare experienced by individual observers from sources located at varying angular distances from the viewing direction. In fact, it is stated that the reactions of three of the ten observers were the opposite of those of the remainder of the observing team in that as the angular distance was progressively increased, significantly lower source brightnesses were required to produce BCD. An average relationship for these three observers has been deduced from the published data and is given in the accompanying drawing.

Differences as marked as these were noted at the Building Research Station when studying the relative glare sensitivities of inexperienced observers taken at random from the general population,[1] so Putnam and Gillmore's results do not come as a surprise; in fact we are comforted by the fact that other workers also get their anomalous observers. In view of these evident nonconformities in individual glare judgments, the best practical expedient is to specify design data which will satisfy a majority of the general population. In this respect, we still feel that we were wise in our 1950 paper[2] to advocate that for small displacements of the glare source (up to about 20 degrees) the position effect should be ignored.

Even if Putnam and Gillmore's seven selected observers are alone considered, it is seen from the accompanying drawing that for angles greater than 15 degrees their reactions to the source displacement effect are less than those reported by Luckiesh and Guth[3] and by the writers.[2]

*Department of Scientific and Industrial Research, Building Research, Building Research Station, Garston, Watford, Herts., England.



COMPARISON BETWEEN RESULTS OBTAINED BY
PUTNAM AND GILLMORE ——————
LUCKIESH AND GUTH —·—·—·—
PETHERBRIDGE AND HOPKINSON – – – – –
OF THE GLARE FROM OFF-AXIS SOURCES.

The generally smaller source size used by Putnam and Gillmore is not likely to produce this effect since it can be deduced by comparing the results of Fig. 4 of the present paper with those of Fig. 6 of Putnam and Faucett's paper[4] that with decreasing source size the effect of source position becomes greater rather than smaller. The lower surrounding field brightness used by Putnam and Gillmore might, however, be responsible for the effect. Even so, the negative responses of three of the observers were not obtained by one of the writers when studying discomfort glare in lighted streets[5] at a comparable brightness level.

The results of the further investigations, which the authors indicate are now in progress, are awaited to see whether they offer an explanation for the difference between the present and earlier results. It is very satisfactory, however, that more workers in the field of glare discomfort are coming forward with their anomalies as well as with their conformist results, and we congratulate Professor Putnam and Mr. Gillmore for giving us such comprehensive data.

1. Hopkinson, R. G. and Petherbridge, P.: "Two Supplementary Studies on Glare," *Trans. Illum. Eng. Soc.* (London), Vol. 19, No. 7, pp. 220-224 (1954).
2. Petherbridge, P. and Hopkinson, R. G.: "Discomfort Glare and the Lighting of Buildings," *Trans. Illum. Eng. Soc.* (London), Vol. 15, No. 2, pp. 39-71 (1950).
3. Luckiesh, M. and Guth, S. K.: "Brightnesses in Visual Field at Borderline Between Comfort and Discomfort (BCD)," ILLUMINATING ENGINEERING, Vol. XLIV, No. 11, pp. 650-667 (1949).
4. Putnam, R. C. and Faucett, R. E.: "The Threshold of Discomfort Glare at Low Adaptation Levels," ILLUMINATING ENGINEERING, Vol. XLVI, No. 10, pp. 505-510 (1951).
5. Hopkinson, R. G.: "Discomfort Glare in Lighted Streets," *Trans. Illum. Eng. Soc.* (London), Vol. 5, No. 1, pp. 1-24 (1940).

CHARLES H. REX:* Profesor Putnam's splendid paper and the highly significant data which he is developing will help answer the question: "How good does roadway lighting have to be?"

To greatly expand and extend the use of lighting, it must provide a significant improvement in visual and traffic comfort as well as convenience and safety for night motor vehicle transportation. We all know that public demand and desire for roadway lighting depends on how easy and pleasant it makes night driving. The extent by which night driving is made more attractive, less tense, less fatiguing, will largely determine the extent by which people will want and will enjoy the benefit of roadway lighting. Obviously conditions conducive to night use affect the overall value of the tremendous multi-billion dollar public investment in streets, highways, autos, trucks and buses.

Now, with the data which Professor Putnam has pro-

*Outdoor Lighting Dept., General Electric Co., Hendersonville, N. C.

TABLE A (Rex discussion) — Conversion Factor Data Pertaining to Relative Comfort Ratios to BCD.

Longitudinal Viewing Eye-Level Distance		Actual Distance (D) from Luminaire		Vertical Dimension of Source		Lateral Dimension of Source		Visual Angle Q Subtended by Luminaire Size (w)		Brightness *Luminaires on Driver's Right		Angle* θ Between Luminaire and Line of Sight
in MH	in Feet	in MH	in Feet	in Feet	in View Angle	in Feet	in View Angle	Degrees Square 1° x 1°	Steradians A (Ft.) D^2 (Ft.)	Cd. per Sq. In.	Ft-L	in Degrees
Hypothetical Luminaire Used in I.E.S. Paper, Area 100 sq. in. assumed constant												
3.5	105	3.64	109.3	0.5	16′	1.33	42′	$\frac{16}{60}\times\frac{42}{60}=.185$	$\frac{.5\times1.33}{(105)^2}=.0000603$	100	45,200	16.1
5.0	150	5.10	153.1	0.5	11′	1.33	30′	$\frac{11}{60}\times\frac{30}{60}=.091$	$\frac{.5\times1.33}{(150)^2}=.0000295$	37.5	16,950	11.3
6.5	195	6.57	197.2	0.5	9′	1.33	22′	$\frac{9}{60}\times\frac{22}{60}=.054$	$\frac{.5\times1.33}{(195)^2}=.0000175$	18	8,136	8.5
8.5	255	8.56	256.9	0.5	7′	1.33	18′	$\frac{7}{60}\times\frac{18}{60}=.035$	$\frac{.5\times1.33}{(255)^2}=.0000102$	13	5,876	6.9
10.5	315	10.53	315.9	0.5	5′	1.33	14′	$\frac{5}{60}\times\frac{14}{60}=.019$	$\frac{.5\times1.33}{(315)^2}=.0000067$	9	4,068	5.3
15.0	450	15.03	451	0.5	4′	1.33	10′	$\frac{4}{60}\times\frac{10}{60}=.0047$	$\frac{.5\times1.33}{(450)^2}=.00000328$	6.25	2,825	3.8
Fluorescent Luminaire 21,500 lumen, horizontal, mounting area 560 sq. in. assumed constant												
3.5	115	3.64	109.3	0.66	21′	5.83	2°53′	$\frac{21}{60}\times2\frac{53}{60}=1.009$	$\frac{.66\times5.83}{(105)^2}=.000349$	4.8	2,169	16.1
5.0	150	5.10	153.1	0.66	15′	5.83	2°11′	$\frac{15}{60}\times2\frac{11}{60}=.56$	$\frac{.66\times5.83}{(150)^2}=.000171$	3.6	1,627	11.3
6.5	195	6.57	197.2	0.66	12′	5.83	1°42′	$\frac{12}{60}\times1\frac{26}{60}=.285$	$\frac{.66\times5.83}{(195)^2}=.000101$	2.8	1,265	8.5
8.5	255	8.56	256.9	0.66	9′	5.83	1°18′	$\frac{9}{60}\times1\frac{18}{60}=.195$	$\frac{.66\times5.83}{(255)^2}=.0000592$	2.2	994	6.9
10.5	315	10.53	315.9	0.66	7′	5.83	1°4′	$\frac{7}{60}\times1\frac{4}{60}=.124$	$\frac{.66\times5.83}{(315)^2}=.00003878$	1.6	723	5.3
15.0	450	15.03	451	0.66	5′	5.83	4°4′	$\frac{5}{60}\times\frac{44}{60}=.061$	$\frac{.66\times5.83}{(450)^2}=.000019$	1.5	678	3.8

*Based upon driver-observer positions along 1.5 MH longitudinal eye-level at 0.5 MH with respect to luminaires No. 2, 4, etc., as shown in "Luminaire Light Distribution Principles" (December 1955 I.E.)

duced, we will have a basis for numerical ratings of the relative visual comfort provided by roadway lighting systems. The comfort ratings will be expressed in ratios to the BCD, comfort sensation ratings.

Thus the visual seeing effectiveness of roadway lighting will be expressed in terms of (a) relative seeing comfort ratings, and (b) relative visibility rating.

Number ratings such as this will provide the increased knowledge necessary for rapid progress in the proper use of roadway lighting. Additional data for representative roadway lighting conditions should be developed quickly with the high priority which the night traffic situation warrants.

Data similar to those which Professor Putnam has presented will be used in estimating the relative BCD comfort sensation ratings for representative roadway lighting systems. The ratio of BCD ratings will vary as the driver proceeds along the lighted roadway approaching each of the several luminaires in his field of view. Such variations will be averaged over a longitudinal cycle. The brightness of luminaires at distances up to 15 MH (450 feet) will be included.

The general method for using such data and presenting calculated ratings was presented in the 1955 conference paper "Luminaire Light Distribution Principles" published in the December 1955 issue of ILLUMINATING ENGINEERING. It is currently in use by the I.E.S. Subcommittee on Roadway Lighting Principles.

The average pavement brightness is 0.447 footlambert with the hypothetical luminaires used. During the summer Professor Putnam and associates working on an Illuminating Engineering Research Institute grant have developed additional data based upon an average background or surround brightness of 0.1 footlambert to supplement the 0.01 footlambert brightness data presented here.

For the use of the many interested, Table A presents a tabulation of conversion factors for steradians, etc., relating the Putnam data to representative roadway lighting systems.

Professor Putnam and his associates should be congratulated on a major accomplishment which merits the thanks of all those interested in the future of roadway lighting and night motor vehicle transportation.

RUSSELL C. PUTNAM:* The authors greatly appreciate the remarks made by the discussors: Dr. Guth and Mr. Faucett, from their background of experience with investigations of a somewhat similar nature; Mr. Rex, as a street lighting engineer who is interested in the practical application of the results; and Dr. Hopkinson and Mr. Petherbridge, who have carried on such distinguished and valuable researches on glare in England.

The term "steradian" should be familiar to illuminating engineers as it is used in Dr. Guth's and Mr. Faucett's publications and also appears several times in the Standards and Nomenclature section of the *I.E.S. Lighting Handbook*.

Mr. Faucett's suggestion for future work gives some indication of the questions which need to be answered. At present, studies are in progress with multiple simulated incandescent and fluorescent sources against a surround brightness of 0.1 footlambert. This should add much to our present knowledge.

We certainly agree with Dr. Guth and Mr. Faucett that much more work is necessary before the practical application can be made that is so eagerly desired by Mr. Rex. Dr. Guth's comments are particularly pertinent in this regard.

The suggestion of Dr. Hopkinson and Mr. Petherbridge that low surrounding field brightness used in this investigation might account for the differences in slope between the curves of the seven observers and the curves of the other investigators which involve higher surround brightness is a reasonable explanation. At the present time the authors have no explanation of the different results reported by the three observers that are so much in variance with the other seven.

The authors wish to emphasize that this present paper is in the nature of a progress report. The results of this investigation are presented to add a little more data to the mass which is needed by this very large and complex problem.

*Co-author.

Exercise your privilege to vote . . .

in the election of National and Local I.E.S. Officers. Ballots, which were mailed to the voting membership of the Society early in April, must be received by the General Secretary at I.E.S. Headquarters not later than May 26, in order to be counted.

INSTALLATION AT PHILADELPHIA ELECTRIC CO., 211 SOUTH BROAD ST., PHILADELPHIA, PA.

Luminous Ceiling Sections In a Drafting Room

LIGHTING OBJECTIVE: To provide quality lighting in adequate quantity for drafting.

GENERAL INFORMATION: Each bay between columns in the drafting areas measures approximately 14 by 20 feet. Ceiling height is 8 feet 6 inches. Walls and columns are pastel green (40% RF), ceiling is white acoustical blocks (62% RF), flooring is light gray asphalt tile (30% RF), and the file cabinets and furniture are dark (4% RF).*

*Not in accordance with I.E.S. Recommended Practice.

(over)

A.I.A. File No. 31

INSTALLATION: Because this area in the Sales Applications Department of an electric utility might be used to demonstrate luminous ceilings to customers, and partially as a comparative test, luminous ceilings made by two competitive manufacturers were installed. Each uses sixteen 96-inch T-12 standard warm white slimline lamps operated on two-lamp ballasts and arranged in eight 16-foot rows spaced 18 inches on centers. The plenums are 18 inches deep of 80 per cent reflectance white plaster.

The area in the foreground of the photograph uses the Wakefield Ceiling (The Wakefield Co., Vermilion, Ohio) which comes complete with fluorescent lamp channels. This provided an average of 135 footcandles after 2000 hours of operation.

In the area shown at the right is installed a Benjamin Electric Mfg. Co. (Des Plaines, Ill.) Panel-Glo ceiling. Fluorescent channels used in this area are Metalcraft #C1-96-430. This installation provided an average of 125 footcandles after 2000 hours of operation.

The brightness distribution in this room is as follows:

ceiling	13 ft-L
walls and columns	16 ft-L
furniture	1 ft-L
floor	19 ft-L
Benjamin luminous ceiling (at 45°)	161 ft-L
Wakefield luminous ceiling (at 45°)	177 ft-L

Lighting designed by C. W. Rudolph, Philadelphia Electric Co.; Architect: Thalheimer and Weitz, Philadephia; Electrical contractor: Howard P. Foley Co., Philadephia.

Lighting data submitted by George T. Anderson, Jr., Philadelphia Electric Co., as an illustration of good lighting practice and to aid in the design of similar installations.

Published by the Committee on Publications of the Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.

Mercury Floodlighting— Its Advantages and Limitations

By JAMES R. BALE

In the twenty-two years since the first practical application of mercury lighting was made at the Chicago World's Fair in 1934, the mercury lamp has become firmly established in the fields of industrial lighting and streetlighting as one of the most efficient and economical sources of light available. With the developments that have been accomplished in just the past few years, such as the isothermal bulb, higher efficiencies, longer life, greatly improved color, and a whole family of lamp sizes, an increasing interest has developed, both with the consumer and in the lighting industry, in new applications for mercury lighting. It is not surprising, therefore, to note that recently there has been considerable interest, particularly on the part of the consumer, in the application of the mercury source to general floodlighting.

Actually the mercury lamp has already been used quite extensively in the broad distribution, low mounted porcelain enameled type of floodlight for low intensity, large area lighting, and it has proved very successful for this type of application. It has also been used to some extent for building floodlighting where the blue white color of the clear mercury lamp was desirable. The interest now, however, seems to be in extending its use to all types of floodlighting, particularly sportslighting.

There are several reasons, aside from the novelty effect accompanying any new type of application, for considering the mercury source for general floodlighting application. In both exterior industrial lighting and in sportslighting where floodlights may be on high poles, towers, or structures, they are usually difficult to reach for cleaning and relamping. In these instances, the 7000-hour life, at which the greater portion of the mercury lamps is now rated, is indeed an appealing feature from both an economic and convenience viewpoint. The high efficiency of the mercury source, nearly 2½ times the efficiency in lumens per watt of the filament source, is another feature which in this era of high labor and equipment costs is making the customer ask more and more often, "What about mercury for floodlighting?"

Nearly all the floodlights offered today for use with the mercury source are units that were designed for the filament lamp, or modifications of the same. This paper represents a study of the economic and photometric characteristics of these floodlights.

The modern floodlight is, to a greater extent perhaps than any other type of luminaire, a precise optical instrument. It depends for its performance on the degree of light control that can be achieved from a source enclosed in some combination of a spherical, elliptical, or parabolic contour, and it is a basic photometric concept that the performance of a floodlight is determined largely by the source size and its location in the reflector. Comparing the two- to six-inch length of the mercury arc to the ideal, but hypothetical, point source desired for maximum control, or even to the relatively small size of the incandescent filament, it becomes obvious that the problems of proper light control with the clear mercury lamp in a standard type of floodlight are much more complex than with a filament source. With the fluorescent mercury lamp, which presents a source which is even longer, and from 3½ to 7 inches in diameter, precise control is nearly impossible in standard floodlighting equipment.

There are certain basic factors that have a definite bearing on the relative merit of any floodlight; among them are beam spread, beam candlepower, beam shape, beam efficiency and overall cost. A survey was made of the mercury floodlighting photometric data of several of the major floodlighting equipment manufacturers to determine how the factors mentioned above are affected by the mercury source. The following characteristics were found to be typical:

Beam Spread

A full range of IES beam types from type 2 to type 6 are possible with the clear mercury lamp,

A paper presented at the National Technical Conference of the Illuminating Engineering Society, September 17-21, 1956, Boston, Mass. AUTHOR: Westinghouse Electric Corp., Cleveland, Ohio.

depending on the reflector contours, reflector finish, and cover lens employed. With the fluorescent mercury lamp, however, the beam spreads obtainable are limited primarily to the wide distribution; IES types 5 and 6.

Beam Candlepower

The principal distinguishing characteristics of the mercury floodlight are found in the distribution of the candlepower throughout the beam. Fig. 1 compares some typical mercury and filament distribution curves for a 16-inch general purpose enclosed floodlight with a specular reflector. With either the 400-watt, 700-watt or 1000-watt clear mercury lamp, good average maximum candlepower values of upwards of 100,000 candlepower are obtainable with a specular reflector and a plain lens. This combination of lamp reflector, and lens, however, results in the characteristic beam shape illustrated by the curve of the 400-watt E-H1 lamp, plain lens shown by curve (a) in Fig. 1. The narrow highly concentrated peak in the candlepower curve is obtained in varying degrees both when the lamp is operated horizontally and when it is operated vertically and it is a result of the length of the mercury arc, and its position relative to the focal point of the enclosing contour.

The high intensity peak is narrow enough that its existence is not generally apparent from the isocandle curves unless the maximum candlepower is especially noted, but the maximum candlepower in some reflector shapes may be 2-3½ times as great as the average maximum candlepower indicated on the standard photometric test report. This might be compared with an average ratio of approximately 1.2:1, maximum to average maximum, for a typical filament floodlight. The effect of this type of distribution on the degree of uniformity obtainable, is illustrated in Fig. 2.

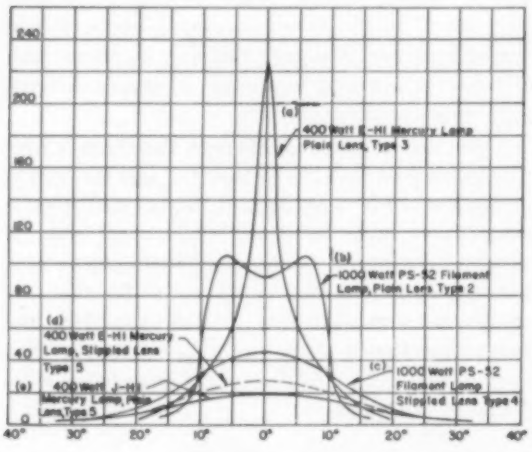


Figure 1. Typical horizontal candlepower distribution curves for a general purpose floodlight with a specular reflector.

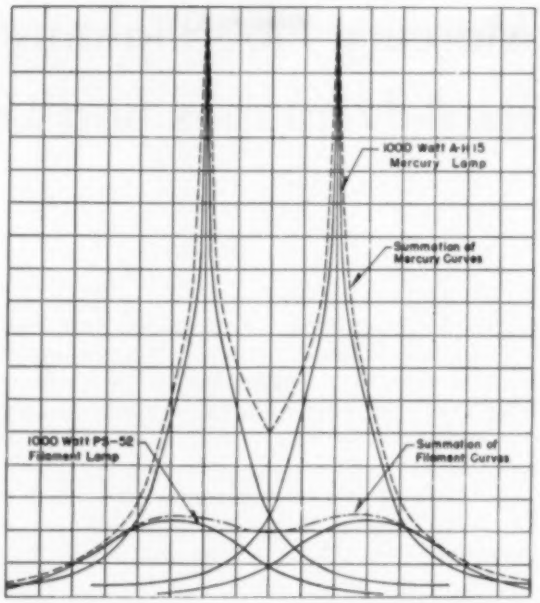


Figure 2. Comparison of uniformity obtainable with typical filament and mercury floodlights with plain lens and specular reflector. Both units are NEMA-IES Type 5 spaced to obtain average maximum candlepower at midpoint between aiming locations.

In Fig. 2, both the incandescent and the mercury floodlights are spaced to provide a total candlepower midway between the aiming points of the luminaires equal to the average maximum candlepower of each individual unit. As the spacing between maximum and minimum points is increased to obtain lower levels of illumination, the uniformity of illumination achieved decreases quite rapidly due to the steep slope of the distribution curve. The high ratio of maximum to average maximum candlepower can be substantially reduced by the use of a diffusing lens or an etched reflector but a simultaneous sharp decrease in available peak candlepower results; curve (d), Fig. 1. The use of the fluorescent mercury lamp for floodlighting purposes is restricted largely by the wide beam spreads and low peak candlepower values that are characteristic of a large source. Even with the 1000-watt lamp, a maximum of around 20,000 candlepower is all that can be obtained. This limits the application of the fluorescent mercury lamp primarily to general area lighting and relatively

close in building floodlighting where short beam throws are required. As stated earlier it has been used quite extensively and very satisfactorily for this purpose.

The satisfactory application of the clear mercury lamp in the sportslighting type of floodlight, where the lamp is operated in a vertical or near vertical plane, is hampered to some extent by the vertically elongated beam pattern resulting, as illustrated in Fig. 3A. An examination of the photometric data for this type of unit also indicates an undesirable tendency in the smaller diameter floodlights for the maximum candlepower zone to fall from 1½ to 10 degrees below the center of the beam.

Beam Efficiency

The actual beam efficiencies of mercury floodlights are lower in most instances than the efficiencies of equivalent filament floodlights. A comparison of test data will show a 5 to 10 per cent reduction in beam efficiencies for type 2, 3 and 4 mercury floodlights with respect to their filament equivalents, and a 10 to 20 per cent reduction for type 5 and type 6 mercury floodlights. On the basis of lumens per watt, however, the mercury units will average from 1½ to 2 times more efficient. This, of course, is of importance primarily in the economic analysis which will be discussed in detail in a following paragraph.

There are several other characteristics of the mercury source that must be considered in determining its desirability for floodlighting application.

Stroboscopic Effect

A characteristic of the arc source which is undesirable in some industrial and all sportslighting applications of the mercury source is the stroboscopic effect. The arc of the mercury lamp, operating on 60-cycle alternating-current is struck, momentarily extinguished, and restruck 120 times a second. This produces a noticeable flicker on rapidly moving objects that causes the observer to see multiple images of the object, and tends to give a false impression of its speed. This might be hazardous in the presence of moving machinery, and might affect considerably the ability of players in an athletic contest to perform with their maximum ability. To minimize the stroboscopic effect in a mercury installation a two-lamp lead-lag ballast may be employed or alternate lamps may be connected to alternate phases of a 3-phase distribution system. For maximum protection both methods might be used. The addition of filament lighting to a mercury installation will also aid in reducing stroboscopic effect.

Outages

When a momentary interruption in the power supply occurs with a mercury lamp the light is extinguished. A period of from 4 to 8 minutes is then required before the vapor pressure in the mercury lamp is reduced sufficiently to permit the arc to restrike. Therefore, whenever mercury is used for applications involving the presence of moving machinery or other dangerous objects, or groups of spectators, it is important that some filament lighting be incorporated in the installation, either as a regularly operating portion of the lighting system or as standby lighting for emergency use in case of an unexpected power failure.

Color

The desirability of the color of the light emitted by the mercury arc for any particular application depends primarily on the psychological reactions of the group being served by the lighting system. As long as an equal quantity of illumination is provided, scientific investigations have shown that the color of the illuminant has no effect on the ability to see! In most instances, however, the color of the light from the clear mercury lamp would not be desirable for floodlighting applications serving the general public. Women in particular object to the color distortion of the complexion, and to many items of clothing that would result. Color rendition can be successively improved by the use of the S-H1 lamp and the J-H1 lamp, in that order, but only with the simultaneous reduction in candlepower and broadening of the beam.

How does the mercury lamp compare economically for flood lighting use? The cost analysis shown in Table I compares a 1500-watt filament system operating at 10 per cent over rated voltage, column 1; and a 1000-watt filament system operating at rated voltage, column 2; to 6 mercury systems, columns 3-8, utilizing both the 400-watt and 1000-watt clear mercury lamps operated at rated voltage on 120, 240 and 480-volt circuits, and the 1000-watt clear mercury lamp operated at 50 per cent over wattage on both a 240-volt and 480-volt circuit.

The advantage of the high voltage system is that it enables the use of a simple reactor type ballast which permits a considerable savings in ballast costs. Overwattage operation permits a reduction in the number of floodlights required to provide a given illumination level; a feature which can result in a considerable savings in equipment costs. It should be noted that overwattage operation of a mercury lamp requires a ballast especially designed for that purpose. An attempt to accomplish the

TABLE 1 — Cost of Lighting Analysis for Comparison of Incandescent and Mercury

	LIGHTING SYSTEM NUMBER	1[1]	2[1]	3[2]	4[2]	5[2]	6[2]
DESCRIPTION OF LIGHTING SYSTEMS	1. Type of lamp (fil., merc., preheat fluor., slimline, etc.)	Filament	Filament	Mercury	Mercury	Mercury	Mercury
	2. Lamp description	1500W PS-52	1000W PS-52	1000W A-H15	1000W A-H15	1000W A-H15	1000W A-H15
	3. Type of luminaire	Sports Floodlight	General Purpose	General Purpose	General Purpose	General Purpose	General Purpose
	4. Number of lamps per luminaire	one	one	one	one	one	one
BASIC DATA	5. Rated initial lamp lumens per luminaire { Lamp / Beam	44,955[4] 23,088	21,600[5] 10,975	55,000[5] 21,116	55,000[5] 21,116	80,000[6] 30,714	80,000[6] 30,714
	6. Lamp life (hrs.)	300	1,000	7,000	7,000	2,000	2,000
	7. Watts per luminaire (including auxiliary)[7]	1,914	1,100	1,163	1,144	1,731	1,707
	8. Coefficient of utilization	Equivalent to 240 Unit NEMA Class C Baseball					
	9. Maintenance factor	.75					
	10. Number of luminaires	240	504	264	264	180	180
	11. Average footcandles maintained	30 ft-c Infield 20 ft-c Outfield					
	12. Energy rate ($ per kwh)	$ .02	.02	.02	.02	.02	.02
	13. Estimated burning hours per year	300	300	300	300	300	300
INITIAL COST	14. Net luminaire cost (each)	$ 53.02	51.48	64.35	64.35	77.00	77.00
	15. Net additional accessory cost per luminaire	$ 93.58	79.11	188.27	143.26	208.29	175.54
	16. Estimated wiring & installation cost per luminaire	$ 15.77	13.24	19.30	19.05	22.96	22.71
	17. Net initial lamp cost each (list less 30%)	$ 2.98	1.96	37.80	37.80	37.80	37.80
	18. Net initial lamp cost per luminaire (4×17)	$ 2.98	1.96	37.80	37.80	37.80	37.80
	19. Total initial cost per luminaire (14+15+16×18)	$ 165.35	145.79	309.72	263.46	346.05	313.05
	20. TOTAL INITIAL COST (10×19)	$ 39,684	73,478	81,766	69,553	62,289	56,349
ANNUAL FIX. CHG.	21. Initial cost per luminaire less lamps (14+15+16)	$ 162.37	143.83	271.92	225.66	308.25	275.25
	22. Total initial cost less lamps (10×21)	$ 38,969	72,490	71,787	59,574	55,485	49,545
	23. ANNUAL FIXED CHARGES (15%[8] of 22)	$ 5,845	10,874	10,768	8,936	8,323	7,432
ANNUAL OPERATING COSTS	24. Annual no. lamp replacements (4×10×13÷6)	240	151	11	11	27	27
	25. Annual cost of replacement lamps (17×24)	$ 715.20	295.96	415.80	415.80	1,020.60	1,020.60
	26. Annual cost of replacement parts (starters, etc.)[9]	$ 389.69	724.90	717.87	595.74	554.85	495.45
	27. Total annual maintenance material cost (25+26)	$1,104.89	1,020.86	1,133.67	1,011.54	1,575.45	1,516.05
	28. Estimated labor cost to replace one lamp	$ 1.00	1.00	1.00	1.00	1.00	1.00
	29. Total labor cost to replace lamps (24×28)	$ 240.00	151.00	11.00	11.00	27.00	27.00
	30. Estimated cleaning cost per luminaire	$ 2.00	2.00	2.00	2.00	2.00	2.00
	31. Number of cleanings per year	one	one	one	one	one	one
	32. Annual cleaning cost (10×30×31)	$ 480.00	1,008.00	528.00	528.00	360.00	360.00
	33. Total annual maintenance labor cost (29+32)	$ 720.00	1,159.00	539.00	539.00	387.00	387.00
	34. Total Annual Maintenance Cost (27+33)	$ 1,825	2,180	1,673	1,551	1,962	1,903
	35. Annual Energy Cost (7×10×12×13÷1000)	$ 2.756	3,326	1,842	1,812	1,869	1,844
	36. TOTAL ANNUAL OPERATING COST (34+35)	$ 4,581	5,506	3,515	3,363	3,831	3,747
TOTAL AND REL. COSTS	37. TOTAL ANNUAL COST (23+36)	$ 10,426	16,380	14,283	12,299	12,154	11,179
	38. Relative Annual Cost	1.00	1.57	1.37	1.18	1.17	1.07
	39. Annual Cost per Footcandle (37÷11)						
	40. Relative Annual Cost per Footcandle						

[1] 120-volt secondary.
[2] 240-volt secondary.
[3] 480-volt secondary.
[4] Lamps operated at 10 per cent over rated voltage.
[5] Lamps operated at rated voltage or wattage.
[6] Lamps operated at 50 per cent over wattage.
[7] Plus 10 per cent line loss.
[8] Usually 15 per cent, assuming 10-year amortization with 5 per cent allowance for taxes, insurance and interest.
[9] 1 per cent of line 22.

same results by operating a standard ballast on the low voltage taps is likely to raise transformer temperatures beyond safe limits.

Columns 9 and 10 show a separate comparison in which the cost of increasing the illumination level on an existing field is compared using all filament lighting for system 9 and a combination of filament and mercury for system 10.

All the installations represented in the cost analysis were designed to provide a total quantity of lumens equal to the quantity required to produce the illumination levels specified for a NEMA class C baseball field. Although the 1000-watt filament lamp is not generally used for this particular application, the number of units needed to meet the stated illumination requirements will offer an

Floodlighting Systems.

	7[1]	8[2]	9[1]	10[1,2]	
	Mercury	Mercury	Filament	Filament	Mercury
	400W	425W	1500W	1500W	1000W
	E-H1	A-H17	PS-52	PS-52	A-H15
	General Purpose	General Purpose	Sports Floodlight	Sports Floodlight	General Purpose
	one	one	one	one	one
	21,000[5]	21,000[5]	44,955[4]	44,955[4]	80,000[6]
	8,838	8,838	23,088	23,088	30,714
	7,000	7,000	300	300	2,000
	492	495	1,914	1,914	1,731
	Equivalent to 240 Unit NEMA Class C Baseball				
			.75		
	628	628	240	80	120
		30 ft-c Infield	20 ft-c Outfield		
$	.02	.02	.02	.02	.02
	300	300	300	300	300
$	51.48	51.48	53.02	53.00	64.35
$	126.03	106.39	34.04	76.87	76.87
$	16.41	15.98	13.75	9.11	9.11
$	12.88	14.18	2.98	2.98	37.80
$	12.88	14.18	2.98	2.98	37.80
$	206.80	188.03	103.79	141.96	188.13
$	129,870.00	118,083.00	24,910.00	11,357.00	22,576.00
$	193.92	173.85	100.81	138.98	150.33
$	121,782.00	109,178.00	24,194.00	11,118.00	18,040.00
$	18,267.00	16,377.00	3,629.00	1,668.00	2,706.00
	27	27	240	80	18
$	347.76	382.86	715.20	238.40	680.40
$	1,217.82	1,091.78	241.94	111.18	180.40
$	1,565.58	1,474.64	957.14	349.58	860.80
$	1.00	1.00	1.00	1.00	1.00
$	27.00	27.00	240.00	80.00	18.00
$	2.00	2.00	2.00	2.00	2.00
	one	one	one	one	one
$	1,256.00	1,256.00	480.00	160.00	240.00
$	1,283.00	1,283.00	720.00	240.00	258.00
$	2,849.00	2,758.00	1,677.00	590.00	1,119.00
$	1,854.00	1,865.00	2,756.00	919.00	1,246.00
$	4,703.00	4,623.00	4,433.00	1,509.00	2,365.00
$	22,970.00	21,000.00	8,062.00	8,248.00	
	2.20	2.01	1.00	1.02	

accurate comparison with the various mercury systems no matter what the application.

Columns 9 and 10 are based on increasing a 160-unit semi-professional class installation to a 240-unit class C installation, utilizing in as much as possible all existing equipment. An assumption was made, however, for this portion of the analysis, that all of the existing floodlights were beyond redemption and all new floodlights were used for both installations.

An assumption was also made that the units were all operated 300 hours a year at an energy rate of two cents per kilowatt hour.

Examining first columns 1-8 of Table I, line 20 shows that the 1500-watt filament system, plan 1, has the lowest total initial cost, with plan 6, the 1000-watt mercury system at 50 per cent overwattage and 480 volts, second lowest. The 400-watt mercury system, operating at 120 volts, plan 7, is the highest in initial cost.

For the total annual maintenance cost, line 34, plan 4, the 1000-watt mercury system at rated watts and 480 volts is the most economical. The principal advantage of this system over plan 6 is, of course, the longer lamp life. Note that the shortened life and high cost of the mercury lamps in plans 5 and 6 destroy the maintenance economic advantage of the mercury system over the 1500-watt filament system. As before the 400-watt mercury system shows no advantage over either of the filament systems in this category.

Under annual energy costs, line 35, all of the mercury systems are substantially more economical than the filament systems. This characteristic is one of the basic attractions of a mercury system.

Combining the above categories we have the Total Annual Cost, line 37, and the Relative Annual Cost, line 38, with Plan 1 as a base.

This analysis indicates that at 300 hours a year and two cents per kilowatt-hour the mercury systems do not show any advantage over a typical filament sportslighting installation although the 1000-watt mercury systems do show marked economic advantage over a general floodlighting system. Figs. 4 and 5 indicate how the relative annual cost of each system varies with the energy rate and number of hours of operation.

Fig. 4, showing the effect of energy rate on the relative annual cost of the various systems, indicates that mercury does not justify itself economically when compared to a 1500-watt filament system operated at overvoltage, unless an energy rate of approximately 4 cents per kilowatt hour is encountered. All of the 1000-watt mercury systems are more economical than the 1000-watt filament system at 300 hours of operation per year.

On the basis of hours of operation, Fig. 5, any of the 1000-watt mercury systems will prove more economical than either of the filament systems at approximately 1100 hours of operation a year with an energy rate of two cents per kilowatt hour, while the 400-watt mercury systems require approximately 2800 hours per year to justify their

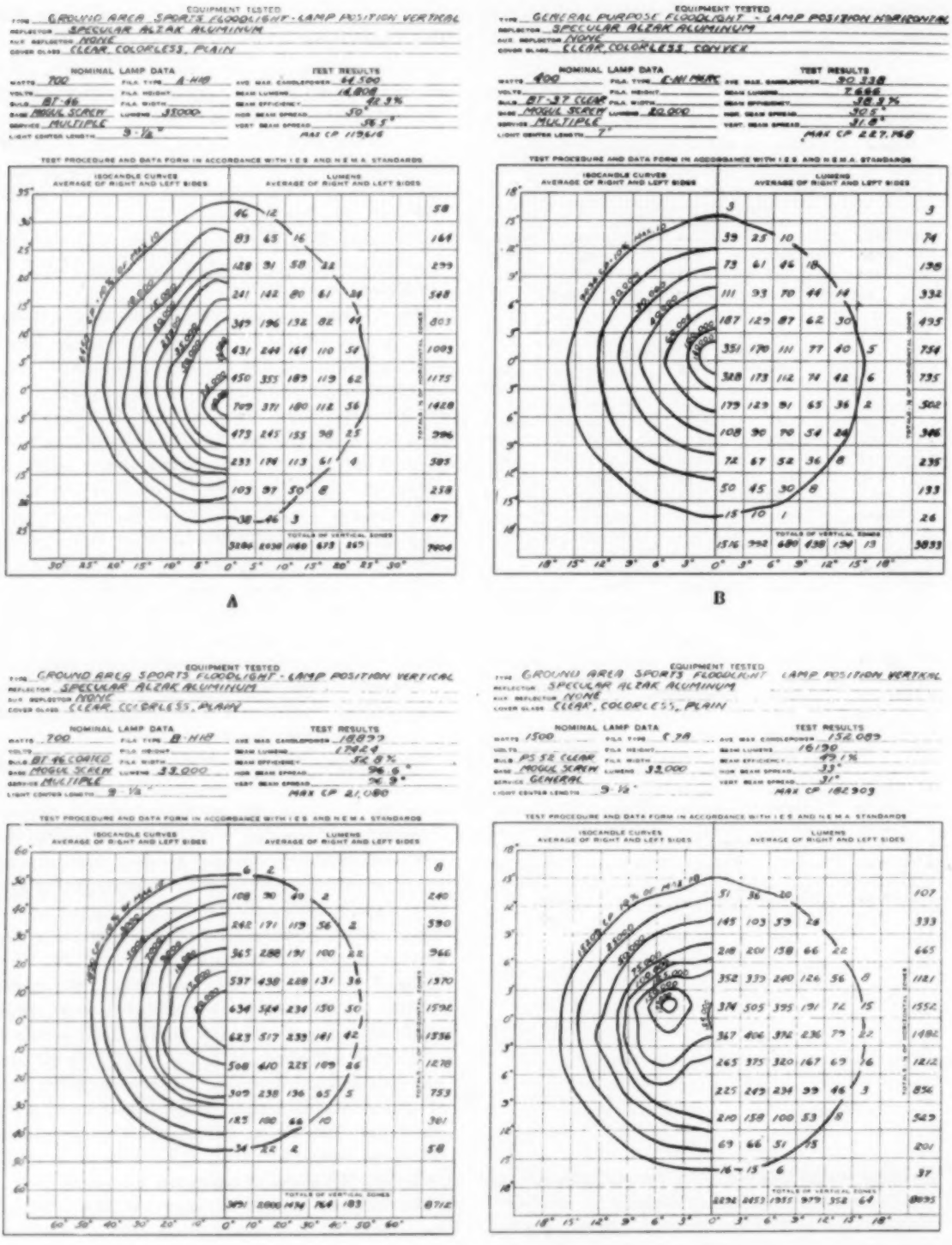


Figure 3. Typical mercury floodlight curves showing the candlepower distribution, beam shape and other photometric characteristics for various lamps and floodlight types as compared to the characteristics of a filament floodlight.

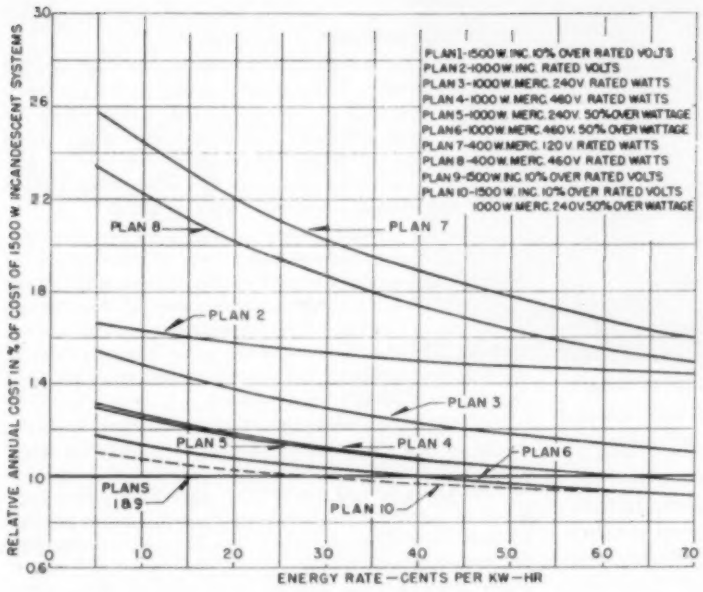

PLAN 1-1500 W. INC. 10% OVER RATED VOLTS
PLAN 2-1000 W. INC. RATED VOLTS
PLAN 3-1000 W. MERC. 240 V. RATED WATTS
PLAN 4-1000 W. MERC. 460 V. RATED WATTS
PLAN 5-1000 W. MERC. 240 V. 50% OVER WATTAGE
PLAN 6-1000 W. MERC. 460 V. 50% OVER WATTAGE
PLAN 7-400 W. MERC. 120 V. RATED WATTS
PLAN 8-400 W. MERC. 460 V. RATED WATTS
PLAN 9-1500 W. INC. 10% OVER RATED VOLTS
PLAN 10-1500 W. INC. 10% OVER RATED VOLTS
1000 W. MERC. 240 V. 50% OVER WATTAGE
PLAN 8
PLAN 7
PLAN 2
PLAN 3
PLAN 5
PLAN 4
PLAN 6
PLANS 1 & 9
PLAN 10
RELATIVE ANNUAL COST IN % OF COST OF 1500 W. INCANDESCENT SYSTEMS
ENERGY RATE—CENTS PER KW-HR

Figure 4. Effect of energy rate on relative annual cost of equivalent mercury and incandescent floodlighting systems — 300 burning hours per year.

use for sportslighting or 1300 hours plus to justify their use over a 1000-watt filament system for general floodlighting. As indicated by columns 9 and 10 of Table I, at 300 hours per year and two cents per kilowatt hour the cost of increasing an existing system using part mercury and part filament is for all practical purposes identical to the system using filament units only, based on a ten-year amortization period. With a period of operation or a power rate much greater than those assumed, the use of part mercury and part filament becomes decidedly advantageous if the mercury lamps are operated at overwattage. The ratio of lumens assumed for the analysis was two lumens of mercury to one of filament.

Conclusions

For all general floodlighting installations operating 300 hours a year or more at an energy rate of ½ cent per kilowatt-hour or more, mercury flood-

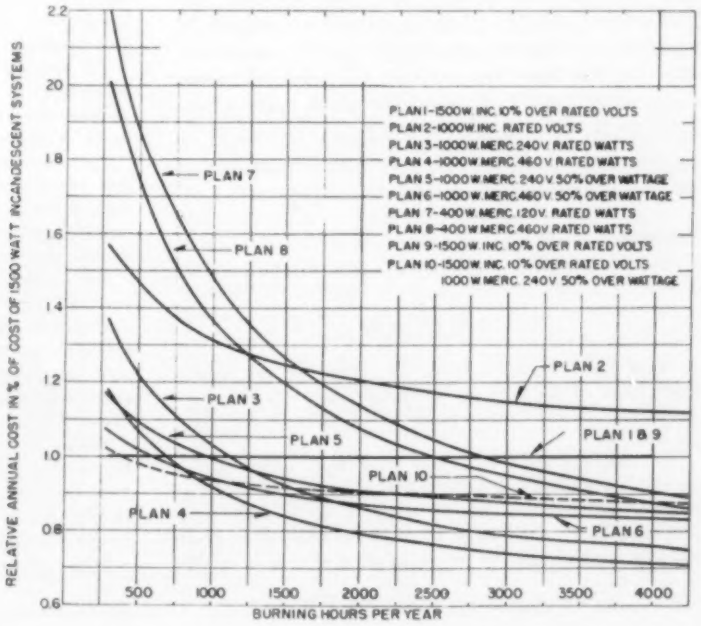

PLAN 1-1500 W. INC. 10% OVER RATED VOLTS
PLAN 2-1000 W. INC. RATED VOLTS
PLAN 3-1000 W. MERC. 240 V. RATED WATTS
PLAN 4-1000 W. MERC. 460 V. RATED WATTS
PLAN 5-1000 W. MERC. 240 V. 50% OVER WATTAGE
PLAN 6-1000 W. MERC. 460 V. 50% OVER WATTAGE
PLAN 7-400 W. MERC. 120 V. RATED WATTS
PLAN 8-400 W. MERC. 460 V. RATED WATTS
PLAN 9-1500 W. INC. 10% OVER RATED VOLTS
PLAN 10-1500 W. INC. 10% OVER RATED VOLTS
1000 W. MERC. 240 V. 50% OVER WATTAGE
PLAN 7
PLAN 8
PLAN 2
PLAN 3
PLAN 5
PLAN 1 & 9
PLAN 10
PLAN 4
PLAN 6
RELATIVE ANNUAL COST IN % OF COST OF 1500 WATT INCANDESCENT SYSTEMS
BURNING HOURS PER YEAR

Figure 5. Effect of burning hours on relative annual cost of equivalent mercury and incandescent floodlighting systems — energy rate $0.02 per kilowatt-hour.

lighting would definitely have an economic advantage. For sports installations normally using the 1500-watt filament lamp at 10 per cent over rated voltage, an energy rate of approximately four cents per kilowatt-hour at 300 hours, or an operating period of from 600-1150 hours per year, at two cents per kilowatt-hour would be required before a mercury system could be economically justified. Photometrically the fluorescent mercury lamp in existing floodlighting equipment provides such a wide beam and low maximum candlepower that it is of little value for sports lighting if any degree of uniformity is to be maintained. Its use is limited primarily to short distance floodlighting of broad areas such as parking lots, service stations, building fronts, etc., having throws up to a maximum of about 60 feet.

The clear mercury lamp in existing equipment will produce practically any beam spread desired for a given application if the proper reflector size and finish and lens combination is used. However, with the narrower beam units the beam pattern may be distorted or be very narrow in the high candlepower zones making uniformity, where good uniformity is desired, rather difficult to maintain. Where maintenance is a severe problem the long life of the mercury lamp might well outweigh some of its deficiencies.

The study further indicates the need for more equipment especially designed to control to a greater extent the large source characteristics of the mercury lamp.

The mercury source has a definite place in floodlighting application, but until such time as the problems of control which it creates are solved by equipment designed specifically to the characteristics of the mercury source, to produce higher beam efficiencies and improved beam control, the application of mercury to floodlighting should be approached carefully with a full understanding of its special characteristics and its limitations.

Reference

1. Luckiesh, M.: *Light, Vision and Seeing*, D. Van Nostrand Co., 1944.

DISCUSSION

R. R. WYLIE:* I wish to thank the author for what he has contributed to the fund of knowledge constantly being accumulated on the applications of mercury vapor light sources.

Mr. Bale has given us a base point from which we can develop our application techniques to prove to the user that mercury vapor lamps are the most economic method of providing today's necessary levels of illumination in floodlighting applications. An extension of these data to specific examples of longer operating hours would have greatly increased the utilization of the paper.

In review, we find the data are based primarily on clear and stippled lenses. There is another very potent method of controlling the output of mercury vapor lamps, which deserves particular attention. It has been successfully shown that the use of spread or control lenses can produce very high utilization factors when used with clear mercury vapor lamps. Extension of these data would be useful.

The author correctly points out that color-improved mercury vapor lamps are not today very effective for many floodlighting applications. As of the present time, efforts are being made by several manufacturers of floodlighting equipment to overcome this disadvantage. Partial success seems very near. Of course, ideas as to acceptable size of floodlighting equipment will have to change somewhat when the luminaire designs are completed.

One current outstanding use of mercury vapor floodlighting is at the St. Lawrence Seaway construction project. Here 1000-watt A-H15 floodlighting equipment is used to provide adequate (2-5 footcandles) illumination over large areas of construction. Equipment is mounted on 100-foot towers and relatively few luminaires (5 to 10) are supplanting large banks of incandescent luminaires, the structure of which resembles the lighting of a baseball field. Three definite advantages accrue to the user here because of the use of mercury vapor light sources.

(1) Long lamp life is experienced in a portable luminaire, the light source of which can stand vibration, shock and moving, thereby reducing maintenance costs.

(2) Use of fewer luminaires provides modeling of the work area. This permits obstructions, stones and the work to be sharply defined, improving worker efficiency and safety.

(3) Tailoring of reflector-lens combination to the particular task, sometimes using color-improved light sources for local general lighting, but using a standard size lamp permits flexibility in lighting, meantime keeping total number of units at a minimum.

D. R. BROWN:* Mr. Bale has presented a straightforward analysis of mercury and incandescent lighting from a commercial standpoint where applicable to large outdoor area lighting.

The graphic analysis as presented in Fig. 1 would be more effective if a lighter stippled lens were used. It is assumed from the shape of the curve that the stippling was heavy or diffusing lens.

The stroboscopic effect and the method of eliminating this effect shows standard procedure to date. However, there seems to be some interest in the lag-lag ballast which provides favorable operation in cold climate without help for the stroboscopic effect.

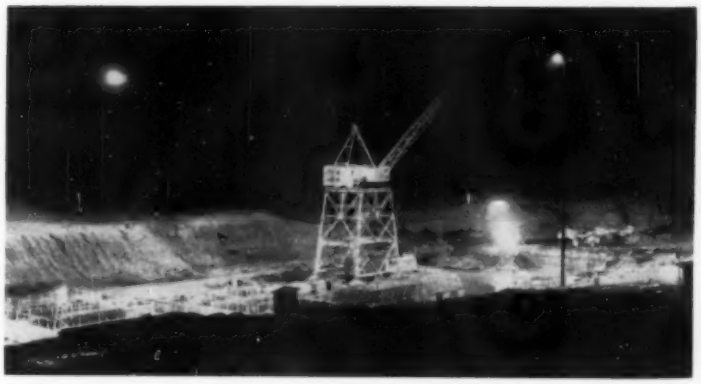
The comparison of mercury and incandescent seems well covered. However, due to the photometric data which are available, the beam characteristics of the mercury lamp do not seem to justify the same coefficient of utilization as used for incandescent lamps. Also the 75 per cent maintenance factor appears to be high for mercury lamps used in known fixtures.

Taking these facts into consideration, it would seem that the number of luminaires used in comparison should not be made on beam lumen comparison only. The author has pointed out that a beam spread variation exists between incandescent and mercury lamps due to size of light source.

With reference to the author's conclusions, I do not under-

*Sylvania Electric Products Inc., Salem, Mass.

*Crouse-Hinds Co., Syracuse, N. Y.



St. Lawrence Seaway construction project. 1000-watt A-H15 floodlighting equipment is mounted on 100-foot towers to light large areas of construction.

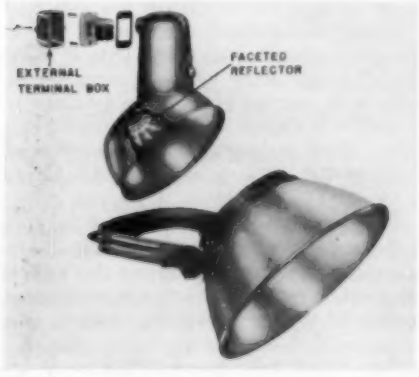
stand the first sentence. It states that for general floodlighting installations operating 300 hours or more per year at an energy rate of one-half cent per kwh mercury has an economic advantage. The previous analysis leads me to believe that this is true only at higher energy rates.

The accompanying photograph shows a typical application of mercury floodlighting which is of interest. For this job, on St. Lawrence Seaway project, floodlights with 1000-watt A-H15 lamps were mounted on 100-foot poles. The blue-green mercury color was found particularly effective.

ROBERT E. FAUCETT:* Mr. Bale is to be congratulated on an outstanding piece of work and his complete discussion of the various aspects to be considered in the choice of mercury or incandescent floodlighting for a given application.

He suggests that in some mercury floodlights the undesirable high ratio of maximum candlepower to average maximum candlepower can be reduced by use of an etched reflector or diffusing lens. This is true; however, this results in broadening the beam spread. There is another method of reducing this high ratio of "maximum to average" without appreciably affecting the beam spread. The photograph shows the faceted reflector principle applied in a recently available incandescent floodlight. This particular unit was primarily designed for incandescent sources, but there is no reason why the faceted reflector principle would not also be applicable to any other type source.

*General Electric Co., Hendersonville, N. C.



Faceted reflector principle applied in an incandescent floodlight.

The striking features of a sectional beam from a faceted reflector are its high projection efficiency, relative freedom from images of the source and uniformity of intensity. The various beams of the conic family (the parabola, the ellipse and the hyperbola) have one property in common; they come from a single real or virtual image. The sectional beam, however, *radiates from a multitude of images* and the beam therefore is composed of a multitude of individual beams that, at a sufficient distance *merge into one*. This results in a more uniform beam distribution, smaller ratio of "maximum to average" with very little effect on the overall beam spread as that is controlled by the characteristics of the main reflector.

The author has pointed out one deficiency of the application of a clear mercury lamp in a unit designed to operate the source in a vertical or near vertical plane. Due to the off-axis position and orientation of the lamp relative to the reflectors there results an elongation of the beam vertically as well as there being a tendency for the maximum candlepower to occur 1½ to 10 degrees below the center of the beam. This emphasizes the need for a family of floodlights to be specifically designed for the application of mercury sources rather than trying to adapt existing incandescent equipment.

The author states that beam efficiencies of mercury floodlights are generally lower than the efficiencies of equivalent filament equipment, but on a wattage basis the mercury units are more efficient than their incandescent counterpart. It should be pointed out, however, that usually, for any given piece of equipment, the efficiency is higher when the incandescent lamp is removed and a mercury lamp substituted. This increase in efficiency is accomplished at a sacrifice in maximum beam candlepower and an increase in beam spread. This is because increase in beam spread produces higher candlepower near the 90-degree zones where the zonal lumen constants have the greater influence.

Neither the beam efficiencies nor the lumen efficiencies of any piece of equipment should be the determining factor in the selection. The most important factor (ignoring economics) is the utilized lumens. In other words, a very efficient unit may not be the thing to use if it does not put the lumens where they are needed. This means that what may be a very efficient unit for a given mounting height, area to be covered and length of throw may be the least desirable unit under a different set of conditions. For example, a mercury unit which has 1½ to 2 times as many

beam lumens per watt as an incandescent unit may best not be used if the area to be lighted is such that only 50 per cent or less of the lumens are utilized.

It is observed from the economic analyses that the total beam lumens are equal in each system. Therefore, the aiming must have been adjusted so that the overall utilization factor is equal in each case.

I believe that the economic analyses chart would be more valuable if the comparisons were made between different systems on the basis of equal footcandles and an optimum aiming chart rather than on the basis of equal overall coefficients of utilization. It is true that by proper selection of equipment of different distributions a fixed value of overall utilization can be obtained by proper aiming; however, the average footcandle level is likely to vary from one system to another. The comparisons of systems should be based upon equal average maintained footcandles with an optimum aiming chart.

ROBERT T. DORSEY:* There are several points in this paper that need clarification.

First, the author uses a maintenance factor of .75 for all equipment. In normal usage this factor is the product of per cent mean lamp lumens throughout the lamp life span under consideration, and the mean decrease in light output caused by the collection of dirt on lamp and luminaire. It seems reasonable to assume that the second factor will be similar for all equipment under consideration. However, the first factor varies greatly with lamp type. The 1500-watt PS-52 averages approximately 82 per cent of rated initial lumens when operated at rated voltage and this value is essentially the same when operated at 10 per cent overvoltage. The mean lumens of the 1000-watt PS-52 are approximately 86 per cent of rated initial based on many tests of lamps on the market.

On the other hand, the mean lumens of the H4000-E1 are about 78 per cent of rated initial and the H1000-A15 is 65 per cent. The above values are for operation at rated watts. It can be expected that operation at 150 per cent watts would result in substantially lower mean lumens.

The maintenance factor of .75 which is recognized by IES and NEMA as a typical figure for enclosed floodlights has not been divided as to lamp and dirt depreciation. For purposes of this discussion, however, assume it applies to 1000-watt units. On the basis of the values already given, the approximate maintenance factors for each lamp type would be as follows: 1500-watt PS-52, .71; H400-E1, .68; H1000-A15 (rated watts), .57; H100-A15 (150 per cent watts), probably below .50.

Since initial and operating costs are in direct proportion to maintenance factor, the results of this study will be considerably altered if these corrected values are used.

We agree with the author that straight mercury is not desirable from the color rendition standpoint in areas serving the general public. In addition, in these areas, any system using only mercury lamps — either clear or color improved — would be undesirable because of the possibility of a momentary voltage interruption or a dip below the voltage at which lamps will operate.

On the other hand, it is agreed that mercury has an important place in floodlighting. It is excellent for some forms of landscape lighting; it provides interesting contrasts in building floodlighting, and in combination with other sources will have advantages for parking lots and sports lighting — just to mention a few.

*General Electric Co., Cleveland, Ohio.

W. S. TILL:* In connection with operation of the 1000-watt A-H15 mercury lamp at 1500 watts, which Mr. Bale shows as one of a number of systems that might be used for floodlighting, I would like to mention that this lamp can also be operated at 1400 watts by use of two 700-watt mercury ballasts, properly connected in parallel. If desired, one of these ballasts can be switched off by remote control or by time clock control after midnight, so that the lamp will burn thereafter at only 700 watts. This arrangement is expected to lead to better lamp life and lumen maintenance than if the A-H15 were operated at 1500 watts for the entire time. It is anticipated that average lamp life will be approximately 4000 to 6000 hours under such conditions of operation. Initial lumens will be approximately 74,000 at 1400 watts and 35,000 at 700 watts.

The statement is made that the color of light from a clear mercury lamp would not be desirable for floodlighting applications serving the general public. Women, in particular, are said to object to the color distortion of the complexion and of many items of clothing. I think that this point is exaggerated, although I do not mean to deny that the distortion occurs. There has been practically no difficulty with mercury lamp color in street lighting applications or in its use in parking lots. At the relatively low footcandle levels that are generally involved in such applications, color discrimination is rather poor no matter what the source. Therefore the color of mercury lighting is more acceptable for floodlighting than might at first be thought likely. In fact, the distinctive appearance of the entire area lighted with mercury lamps is much more apparent than the individual colors within its lighted space. Such a distinctive appearance is often very desirable.

LEO DOLKART:** I would like to compliment the author for the manner in which this subject is so expertly handled.

The ever-increasing use of mercury vapor lamps for floodlighting brings out most forcibly the lack of suitable floodlighting equipment specifically designed for mercury vapor lamps. Up to now it has been the custom to adapt floodlighting equipment designed for filament lamps for this purpose. Now that colored floodlighting using the mercury vapor lamp is coming into popularity it is suggested that manufacturers design suitable equipment, specifically made for the use of the various types and sizes of mercury vapor lamps.

CHARLES GALLO:† I make a plea for more careful designation of beam angles of floodlights. Some manufacturers designate as medium beam a floodlight with a beam spread of 75 to 80 degrees. Others will call it a wide beam floodlight. It would seem advisable and clearer to stop using the terms narrow, medium or wide beams, or to do so only when accompanied by the actual degree of beam spread. Then the customer or contractor will know definitely what the beam spread is in degrees, and will not depend on a vague terminology where one manufacturer may call a unit wide beam while another will designate the same as being medium beam.

JAMES R. BALE:†† The author wishes to thank the discussors for their comments and for the interest they have shown in this paper. Most papers of this type would unquestionably be more helpful if some of the data could be extended or

*Westinghouse Electric Corp., Bloomfield, N. J.
**Latin American Export Service, Chicago, Ill.
†Public Service Electric and Gas Co., Newark, N. J.
††Author.

discussed in greater detail, as Mr. Wylie suggests. For obvious reasons, however, the length of such a presentation is limited and it is often impossible to carry the analysis as far as one might like.

Some doubt was raised by Mr. Brown and Mr. Faucett as to the accuracy of using the same average coefficient of utilization for all the layouts in the economic analysis. The author would first like to point out that this analysis was based entirely on the clear mercury source, since the characteristics of the fluorescent mercury source in existing floodlighting equipment (broad distribution and low peak candlepower) somewhat restrict its practical general usage. Through the selection of proper lenses, reflector shapes and reflector finishes, beam spreads closely approximating those obtainable with a filament source are obtainable with the clear mercury lamp. By matching the characteristics of the mercury floodlights used on a particular area as closely as possible to the characteristics of the filament units with which they are to be compared, a similar overall average coefficient of utilization can be achieved without appreciably greater differences in the uniformity of the two lighting plans than inherently exists between the two systems. These differences are illustrated in Fig. 2.

The author must disagree with Mr. Faucett's blanket statement that "for any given piece of equipment, the efficiency is higher when the incandescent lamp is removed and a mercury lamp substituted." If Mr. Faucett is referring to "beam efficiency" his statement is true of the fluorescent mercury or "color improved" lamp only. The following beam efficiencies taken from actual published data are typical examples.

	1000-watt PS-52	400-watt E-H1	400-watt J-H1
General Purpose Floodlight, Specular Reflector, 16-inch Diameter			
Plain lens unit	48.2%	38.3%	55.8%
Stippled lens unit	53.4%	45.8%	
Spread lens unit	54.3%	42.1%	
General Purpose, Heavy Duty Floodlight, Specular Reflector, 16-inch Diameter			
Plain lens unit	37.5%	36%	50%
Stippled lens unit	50%	45%	56.5%
Spread lens unit	44%	40%	52.5%
General Purpose, Ground Area Floodlighting, Vertically Operated Lamp, Plain Lens			
Type 2	44.8%	36.9%	52%
Type 3	48.6%	44.8%	52.5%
Type 5	57.6%	49.4%	42.7%

The "high" efficiencies obtained by the use of the fluorescent mercury source are achieved with a considerable reduction in maximum candlepower and a substantial broadening of the beam.

Mr. Brown's confusion concerning the first sentence of the conclusion indicates that this statement may be somewhat misleading. As shown in Fig. 4, the curves of all the 1000-watt mercury plans lie considerably below the curve of plan 2, which represents a typical general filament floodlighting system operated at rated voltage. Therefore, providing the larger mercury lamps are utilized, which they should be for the most economical installation, mercury will show an economic advantage over the general filament system at any energy rate of one-half cent per kwh or more, above 300 hours of operation per year. The analysis was not carried below one-half cent per kwh. The 400-watt mercury systems would require an operating period considerably in excess of 300 hours per year before they would be economically justified.

Mr. Dorsey and Mr. Brown are correct in pointing out some error in the economic analysis due to the use of a constant maintenance factor. Recent tests, however, indicate lumen maintenance figures substantially higher than those quoted by Mr. Dorsey. The poorest maintenance would result with the 1000-watt mercury lamp operated at 50 per cent overwattage.

Current lumen maintenance studies show possible overall maintenance factors of more than 60 per cent for the 1000-watt mercury lamp operated at 1500 watts, and from 65 to 70 per cent for the 1000-watt lamp at rated wattage. Little or no difference exists between the lumen maintenance of the 400-watt mercury lamps and the filament lamps. These differences in utilization will alter slightly the exact relationship between the various types of installations but they will not alter their relative positions in the analysis. The large mercury lamps still show an economic advantage over the general filament system (operated at rated voltage) at 300 hours or more of operation per year, over the complete range of energy rates shown. Considerably longer hours of operation or higher energy rates would be necessary for the mercury to compete economically with the filament system at 10 per cent overvoltage.

The author joins Mr. Gallo in the opinion that the beam spreads of floodlighting equipment should be designated by the IES type number rather than by the terms wide, medium or narrow beam. The meaning of the word designations is rather obscure and gives little indication of the exact category of beam spread into which the equipment referred to falls.

Applications for Retired Membership

By action of the membership of I.E.S., the new retired membership classifications became effective in the fiscal year beginning last October. Privileges in these new grades, earned by long membership in the Society, include reduced annual dues ($5.00) with continued receipt of all Society mailings including ILLUMINATING ENGINEERING. Such members will be designated as Member, Retired; Associate Member, Retired.

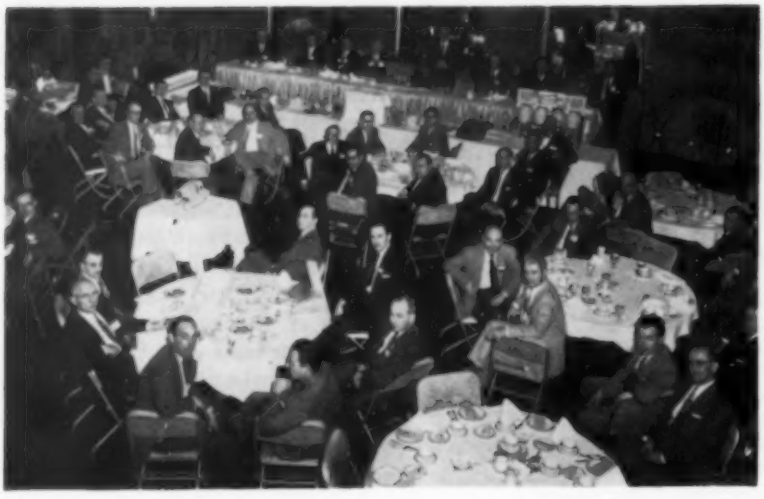
Those who are interested and qualified (at least thirty years of membership and 65 years of age) should address a letter to the General Secretary at Society Headquarters, stating that they have retired from regular occupation in business or profession.

Here and There with I.E.S. Members

Present at the New England Section's January meeting were: left to right: Fred Vorlander, E. J. Perkins, John E. Carr, Jack Bradley, guest speaker George J. Taylor, Section Chairman Carleton Holden, and Norman Ticehurst. Mr. Taylor spoke on office lighting. (Photo courtesy of *New England Electrical News.)*

At the March 5 meeting of the Residence Lighting Committee were, l. to r.: seated, Kaye Leighton, Myrtle Fahsbender, Mary Taepke, Jan Reynolds; standing, Elizabeth Meehan, R. V. Smith, Committee Chairman Frank Marriett, Lloyd Gabler and I.E.S. Technical Director C. L. Crouch. Meeting was held at Society headquarters.

Regional Activities Committee also met at I.E.S. headquarters February 13. Seated are, left to right: C. M. Thompson, C. W. McCormick, Committee Chairman G. J. Taylor, J. Dixon Mitchell and J. A. Schneller; standing: C. E. Waldron, Joe Thomas, J. D. Whitnell, Nelson Warner, John Felton, R. S. Wissoker, proxy for Kenneth Reid, R. M. Taylor and George L. Morris.



Progress Report, with equipment on hand for demonstration, was the featured attraction at the February 21 meeting of the St. Louis Section — with Theodore C. Sargent presenting the report. The meeting was in conjunction with the Residential Lighting Forum and, in addition, was designated Sustaining Member Night, honoring new sustaining members. Attendance was 88.

LIGHTING NEWS

Office and Industrial Forum Sponsored in Cleveland

A five-session forum on modern plant and office lighting was sponsored by the Cleveland Section, I.E.S. and the Cleveland Electric Illuminating Company, March 5 through April 2. The first two of the two-hour sessions were held at the General Electric Lighting Institute at Nela Park, the second two meetings at the Westinghouse Electric Corp. Lighting Studio, and the final one, a dinner meeting, at the Hollenden Hotel Assembly Room.

Program and speakers at the forum were:

Tuesday, March 5

Lighting and the Eye — Q. D. Dobras, Industrial Lighting Engineer, General Electric Co.
Lighting — The Tool of Production — Q. D. Dobras.

Wednesday, March 13

Light Sources — D. R. Phillips, Industrial Lighting Engineer, General Electric Co.

Tuesday, March 19

Selection of Lighting Equipment — W. H. Kahler, Manager Syndicate Sales, Fixture Division, Westinghouse Electric Corp.
Maintenance Pays Off — E. I. Creed, President, C & S Lighting Maintenance Co.

Tuesday, March 26

How To Develop a Lighting Plan — Panel discussion by:
D. W. Rowten, Manager Application Engineering Section
W. H. Johnson, Lighting Engineer
T. Summers, Lighting Engineer
W. R. McMillan, Lighting Engineer, Westinghouse Electric Corp.
Appraising Industrial Lighting System — Panel discussion.

Tuesday, April 2

How Industry Is Putting Lighting To Work — R. E. Mausk, Industrial Sales Department Supervisor, Cleveland Electric Illuminating Co.
Cost of Lighting — F. L. Detwiler, Industrial Sales Representative, The Cleveland Electric Illuminating Co.
A Lighting Tour of Cleveland Industry — F. E. Mueller, Industrial Sales Promotion Representative, Cleveland Electric Illuminating Co.

All Lighting Forum members were guests of the Illuminating Co. at the dinner meeting.

AT THE Charter Meeting of the Yankee Chapter, I.E.S., were, l. to r.: back row, Carleton Holden, New England Section Chairman; John French, Board of Managers; C. W. McCormick, Director; Gordon Root, Board of Managers; Walter Ball, New England Section Vice-Chairman; front row, Donald Provencher, Board of Managers; Arthur C. Brodeur, Jr., Yankee Chapter Chairman; Bart D. Barry, Yankee Chapter Secretary-Treasurer; Ernest H. Carpenter, Board of Managers.

Nine-Week Advanced Course Presented by New York Section

A nine-week practical advanced course in Lighting Design and Layout is being presented by the New York Section of I.E.S., covering commercial, institutional and industrial applications. Each session consists of a ½-hour lecture and 1½-hour application period. Subjects covered are: light sources, fixture types, illumination levels, quality, design and calculations. Specific dates and topics are:

March 5 and 12 — Office Lighting.
March 19 and 26 — School Lighting.
April 2 and 9 — Store Lighting.
April 16 and 23 — Industrial Lighting
April 30 — Outdoor Lighting.

Prerequisite for the course is the Section's "Fundamentals of Illumination" course or its equivalent.

Classes are held at the Consolidated Edison Bldg., 4 Irving Place, New York City. Tuition is $20 to members of IES, AIEE and AIA and employees of IES Sustaining Members; $25 to all others.

Lighting Doesn't Even Show In AID Design Competition

The panel of judges for the Homefurnishings Design Competition of the American Institute of Decorators voted unanimously to omit any award whatever in the lighting category, because there was so little competition.

In all, 16 awards for outstanding designs were announced at the 26th Annual Conference of A.I.D. held April 1 through April 3 at the Statler Hilton Hotel, Dallas, Texas. Awards were presented for printed fabrics, curtain fabrics, novelty fabrics, woven fabrics, soft floor coverings, hard-surface floor coverings, wall coverings, and furniture.

PANEL discussion on "Contractor's Obstacle Course to a Good Lighting Job" was the feature of the January 7 meeting of the Southwestern Section. Left to right are: J. E. Guerrera, Consulting Engineer; W. A. Rogers, Distributor; E. B. Shannon, Moderator; Thomas Moore, Vice-Chairman who arranged the program; Bill Cook, Manufacturers Representative; E. J. Whitlow, Electrical Contractor; and Hal Moseley, Architect.

SOME of the 60 members and guests at the Southwestern Section January 7 meeting.

Survey Analyzes Correspondence School Training

Correspondence schools are becoming an increasingly important factor in the training of engineers, according to a recent survey made by the National Home Study Council of Washington, D. C. More than 32,000 persons enrolled in home study engineering courses in 1955, with a 14 per cent increase estimated for 1956.

Dr. Homer Kempfer, executive director of the group, says that in practically all states Professional Engineer examinations are open to high school graduates with eight years of engineering experience. Today, an estimated 10 per cent of the nation's licensed engineers are home taught.

The rapidly growing home study field — 700,000 enrollees in 1955 — is felt to offer industry an opportunity to meet its needs for scientific and technical personnel of all types by upgrading qualified production line personnel by home study.

NHSC's analysis of the enrollments of 421 correspondence schools showed that three quarters of all those who take home study courses are men, 70 per cent of whom are married. The study charts a steady growth in home study in recent years, and indicates that if this growth continues enrollment in correspondence schools will double in the next ten years.

Five-Way Panel Discussion Featured by Southwestern Section

A special meeting for contractors, architects and engineers was held by the Southwestern Section of I.E.S., January 7, on "Contractors Obstacle Course to a Good Lighting Job." A panel representing five sides of the lighting story discussed methods of bidder selection, practices in fixture specifying, and coordination (?) between architects and engineers.

Panel members were:

Architect — Hal M. Moseley, Member AIA.
Engineer — J. E. Guerrero, Blum & Guerrero, Consulting Engineers.
Electrical Contractor — E. Jerry Whitlow, McClure Electric Co.
Fixture Supply — W. A. Rogers, Rogers Electric Supply Co.
Manufacturers Representative — Billy L. Cook, Close and Cook.

Moderator for the panel discussion was E. B. Shannon, Building Manager, Southland Center.

International Lighting Contest Sponsored by McGraw-Hill

A lighting competition " to foster and encourage the design, sale, installation and use of better lighting . . . " is being sponsored by three McGraw-Hill publications with the cooperation of the National Lighting Bureau of the National Electrical Manufacturers Association. The publications are *Electrical Construction and Maintenance, Electrical Wholesaling* and *Electrical World*. The contest opened March 15 and will close October 25.

Classifications for entries are: industrial, store, office, institution, outdoor, residence. Complete installations, such as an entire store or school, or specific areas within a complete project or a simple lighting technique are eligible.

The competition is open to individuals only, in four classifications of contest-

(Continued on page 13A)

Address Changes should be reported to I.E.S. Headquarters by the first of any month, to insure the uninterrupted mailing of I.E. and other Society communications.

the Two Grand Old Names in Lighting *Announce* the New

Guth Incandescent Lighting Catalog

"*Mr. Holophane*" *says*—

"Glad to have you aboard, Ed. My colleagues tell me your new catalog will prove to be most valuable for Architects and Engineers. Congratulations!"

CHARLES FRANCK,
President
The Holophane Company
New York 17, N. Y.

"*Mr. Guth*" *says*—

"Thank you, Mr. Franck. Our Engineers have had a hey-day with your grand lens-line. The new catalog appears to be a most helpful lighting tool."

EDWIN F. GUTH, SR.
The Edwin F. Guth Co.
St. Louis 3, Mo.

THE NEW GUTH CATALOG features 8 special indexed sections to completely cover the entire new Brascolite line of incandescent fixtures: square and round recessed units with Holophane Controlenses*, surface and suspended fixtures, night lights, bed lights, gym lights, etc. Complete with photograph of each fixture, plus specifications, dimensional drawings (drawn to scale for easy reproduction), coefficients of utilization, light curves, installation information and other technical data.

Also a special 12 page section including complete Lumen and Point-by-Point Charts, features of Guth quality design and construction, as well as description of the famous ALZAK Lifetime Aluminum Finishing Process.

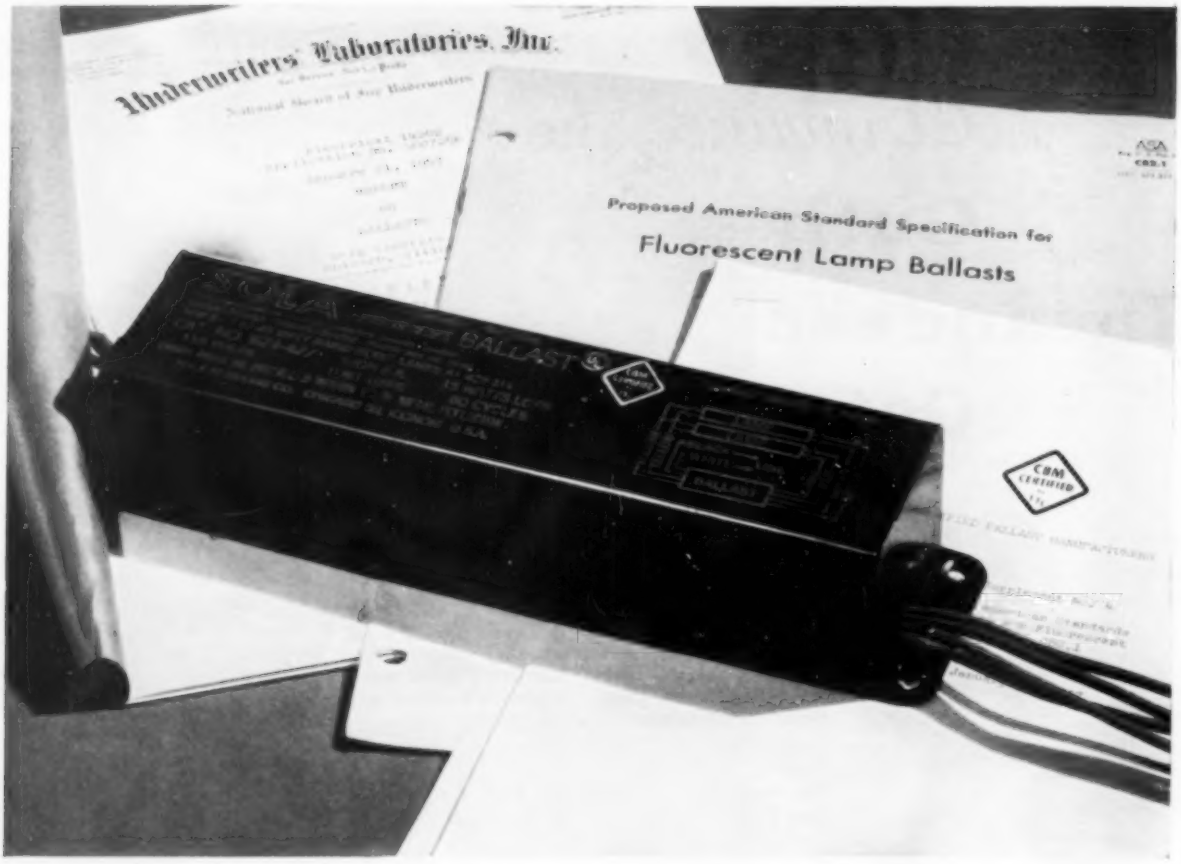
Write on your letterhead for your complimentary copy of this new catalog today.

Celebrating
Our 55th Anniversary
1902-1957

*®Holophane Co.

Guth brascolite

THE EDWIN F. GUTH CO., ST. LOUIS 3, MO.



How these two emblems on a Sola Fluorescent Ballast assure you one high standard of quality

The fluorescent lighting ballasts you buy may carry one or both of two emblems — UL or CBM. The UL (Underwriters' Laboratories) emblem indicates only that a ballast meets *safety* requirements. The CBM emblem indicates that a ballast meets *performance* specifications, set forth by *Certified Ballast Manufacturers*, to assure optimum lamp and ballast operation.

There is no "double standard" of quality in Sola ballasts. In every case where CBM specifications or proposed specifications exist, all Sola ballasts for standard lighting service, meet or surpass the set standards. Every Sola Ballast is UL listed. In addition, the CBM emblem on a Sola Ballast assures you will receive rated lamp life, full light output, and long ballast life. Sola has no "second line" which does not meet the accepted standards — set by lamp and ballast manufacturers themselves — for these factors.

Many people are buying non-certified ballasts, called "UL Ballasts" or erroneously, "UL-Approved" ballasts, in order to save a few cents. Apparently many users believe that UL listing assures satisfactory performance other than safety. *It does not.* UL does *not* test for any operating characteristics that assure efficient, economical performance and long lamp life.

Though it may *sell* for a few cents less, any ballast which does not meet the accepted *minimum* standards specified by CBM, costs *many dollars more* in terms of operating costs. We invite you to send for an accurate engineering report which proves this fact. It is based on figures given by people who make non-certified ballasts.

SOLA *Fluorescent* **BALLASTS**

GET THE FACTS . . . *write today for your copy of Sola's engineering report on the real cost of non-certified fluorescent lighting ballasts.*

4633 W. 16th Street, Chicago 50, Illinois • Bishop 2-1414

CONSTANT VOLTAGE TRANSFORMERS • FLUORESCENT LIGHTING BALLASTS • MERCURY VAPOR LIGHTING TRANSFORMERS
SOLA ELECTRIC CO., 4633 West 16th Street, Chicago 50, Illinois, Bishop 2-1414 • NEW YORK 35: 103 E. 125th St., TRafalgar 6-6464
PHILADELPHIA: Commercial Trust Bldg., Rittenhouse 6-4988 • BOSTON: 272 Centre Street, Newton 58, Mass., Bigelow 4-3354 • CLEVELAND 15: 1836 Euclid Ave., PRospect 1-6400 • KANSAS CITY 2, MO.: 406 W. 34th St., Jefferson 4382 • LOS ANGELES 23: 3138 E. Olympic Blvd., ANgelus 9-9431 • SOLA ELECTRIC (CANADA) LTD., TORONTO 17, ONTARIO: 102 Laird Drive, Mayfair 4554 • Representatives in Other Principal Cities

1957 Regional Conferences, I.E.S.

Region	Place	Date
Southwestern	Holiday Inn Oklahoma City, Oklahoma	April 28-30
Midwestern	Pfister Hotel Milwaukee, Wisconsin	May 9-10
Great Lakes	Pantlind Hotel Grand Rapids, Michigan	May 13-14
Canadian	Sheraton Brock Hotel Niagara Falls, Ontario	May 16-17
East Central	William Penn Hotel Pittsburgh, Pennsylvania	May 23-24
Northeastern	Statler Hotel New York, New York	June 13-14

(*Continued from page* 10A)

ants: Electrical Contractor, Electrical Wholesale Distributor, Architect or Engineer, Electric Utility. Under each contestant division, identical cash prizes are offered for each of the six installation categories. Awards are: first prize — $100; second prize — $50; three more prizes — $25. Honorable mention awards of certificates will also be made.

Entries will be judged on: sales effort, lighting adequacy, lighting quality, artistic appearance, and customer benefits.

Out-of-Print Lighting Books Available at New York Store

Several out-of-print books on illumination are available for sale at the special bookstore of Victor Stammer, 61 Fourth Ave., New York, N. Y. These are: "Art of Illumination," by Bell (1912); "Electrical Photometry and Illumination," by Bohle (1912); "Evolution of the Incandescent Lamp," by Pope (1894); Electric Lighting by Incandescence," by Sawyer (1887).

Utilities Participate In Atomic Power Projects

Sixty-nine electric companies in 31 states and the District of Columbia are participating in one or more of 14 atomic reactor power projects which will add over 1,500,000 kilowatts of capacity to the nation's power supply, according to a statement by Elmer L. Lindseth, Vice-Chairman of the Edison Electric Institute Committee on Atomic Power, to the Joint Congressional Committee on Atomic Energy, February 21.

Seven projects are reported either under construction or in the immediate pre-construction phase, and seven are in various stages of planning, Mr. Lindseth said, in making the industry's annual progress report on development, state and growth of atomic energy for electric power.

French I.E.S. Sets Plans For June Meeting

The annual "national technical conference" of our sister society in France, Association Francaise des Eclairagistes, has been scheduled for June 19-22, in Lyon. A cordial invitation has been extended to all members of I.E.S. to attend this meeting.

Technical sessions will be devoted to industrial lighting, daylighting, home lighting, hospital lighting, the production of light, photometric standards and methods of measurement, and theater lighting.

As has been done in the cities previously host to the meeting — Toulouse, 1952; Dijon, 1953; Monaco, 1954; and Tours, 1956 — the town of Lyon is floodlighting its major monuments and in general modernizing its public lighting installations. Visits to important factories in the neighborhood are planned, as well as an open-air show to be held at the Theatre Antique de Fourvieres.

A detailed program may be obtained from AFE at 33 rue de Naples, Paris 8, France.

Green Bay Study Club Holds "Section-Type" Meeting

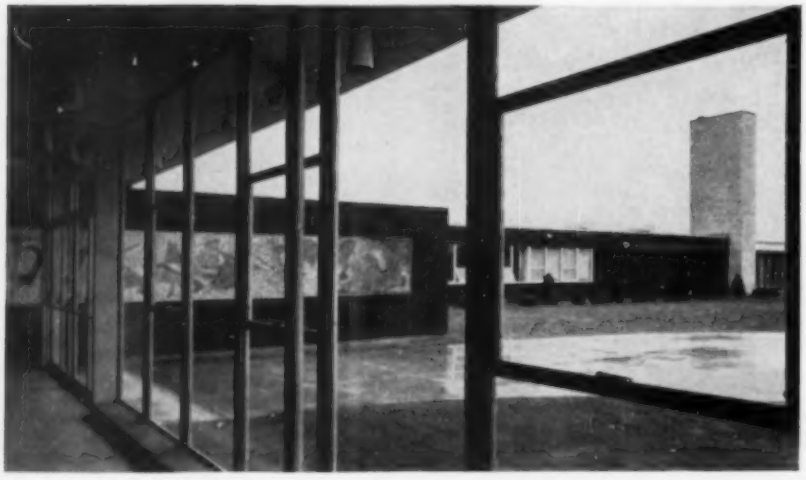
An enviable total of 130 attended the meeting of the Green Bay Study Club, January 23, held jointly with the Green Bay Engineers Club. The program was entitled "Light Touches" and consisted of a discussion of old and new light sources, suggested applications and demonstrations. Speaker was Carl Jensen, District Engineer of Westinghouse Lamp Division, Chicago.

While he was in Green Bay, Mr. Jensen also gave a talk, under the auspices of the Study Club, to a separate meeting of 120 business and professional men, including 20 junior engineers of a club from a local high school.

(*Continued on page* 16A)

GREEN BAY Study Club held a joint meeting January 23 with the Green Bay Engineers Club, attendance being 130. Participating in the meeting were: left to right, Dave Branson, Program Chairman, Green Bay Engineers Club; R. R. Cheney, Chairman, Extension Activities, Milwaukee Section I.E.S.; Carl Jensen, guest speaker; William Dykama, Program Chairman, Green Bay Study Club.

Anderson Clark Junior High School, Los Angeles, Calif.
Architects: Risley and Gould



Hudson Falls, N. Y. High School
Architects: Sargent, Webster, Crenshaw & Folley

Students who attend modern schools like these . . .

New Trier Township High School, Winnetka, Ill.
Architects: Furst, Maher & McGrew
Consulting Engineer: Arthur Bladen of Neiler, Rich & Bladen.

Pattern No. 70 glass in New Trier Township High School cafeteria. Fixtures by Electro Silv-A-King.

Pattern No. 70 glass in Hudson Falls High School Library. Fixtures by Sylvania.

Alba-Lite panels in corridor of Anderson Clark Junior High School. Fixtures by Fluorescent Fixtures of California.

Lenslites in a new auditorium-gymnasium. Fixtures by Eastern Lighting Fixtures.

Alba-Lite panels light this college library. Fixtures by Pittsburgh Reflector.

Pattern 70 panels light this modern grade school classroom. Fixtures by R. & W. Wiley.

see better with modern engineered lighting

From grade school through college, proper lighting is one of the major keys to easier learning.

Engineered lighting with Corning lighting glassware is controlled for seeing. It makes learning easier by helping to provide the correct visual environment.

Through continuing research in light control, Corning has developed engineered lightingware utilizing the optical properties of glass for uniform distribution of adequate, comfortable light.

From corridor to library, from gymnasium to classroom, Corning lightingware in an engineered installation will meet every functional standard for better lighting.

If you're planning a modern building you *are* faced with an illumination problem . . . Bulletin L-100, "Commercial Lighting Application Guide" not only lists and illustrates the many types of Corning lightingware that are available to you but also tells you how to accomplish specific lighting tasks.

Send for your copy today!

Corning Glass Works, 61-4 Crystal Street, Corning, New York

Please send me a copy of Bulletin L-100, "Commercial Lighting Application Guide."

Name.....

Title.....

Company.....

Street.....

City.....Zone.....State.....

Corning means research in Glass

CORNING GLASS WORKS, 61-4 Crystal Street, Corning, N.Y.

(Continued from page 13A)

ABOUT PEOPLE

By unanimous action of Council at its last meeting, **Milton B. Hastings** was elected Member Emeritus of the I.E.S. Mr. Hastings has retired from active participation in the company of which he was President, Powerlite Devices Ltd., Toronto. For over 45 years active in the lighting field, particularly in that of street lighting, he has served the Society as a member of its Committee on Street and Highway Lighting. A charter member of the Board of Managers of the Toronto Chapter, now Section, he served it as Chairman in 1934-1936. In 1953-1954 Mr. Hastings was Vice-President of the Canadian Region of I.E.S.

Curtis Lighting, Inc., has commissioned **J. L. Stair** to prepare a book on commercial and institutional lighting for the company's 60th anniversary this year. Mr. Stair is a consulting lighting engineer and former chief engineer for the company.

The Board of Directors of John C. Virden, Ltd., Toronto, has elected **P. G. Kirkpatrick** as President and General Manager. Mr. Kirkpatrick joined Virden in 1933 as General Manager, was elected Vice-President and General Manager in 1949, and Executive Vice-President and General Manager in 1950.

H. C. McDaniel has been named director of technical information for the Westinghouse Electric Corp. At the same time, **Robert V. McGahey** was appointed manager of technical publicity. Mr. McDaniel, formerly manager of technical information, will continue to supervise activities of both the technical publicity department and the Westinghouse *Engineer* magazine. In addition he will provide technical assistance to the vice-president of information services and will handle special projects as assigned. He will have his office at the company's Pittsburgh offices.

ATTENDING the February 5 meeting of the Residence Lighting Forum Committee were, left to right around table: Katherine Goodall, Lloyd Gabler, Marion Seitz, Lillian Eddy, Virginia Skinner, Jan Reynolds, Eve Freyer and Chairman Ruth Morris.

Appointments of a general sales manager, three division sales managers and two district sales managers for Hubbard and Co. have been announced. **John E. Wennogle** is the new general sales manager at the Pittsburgh headquarters. **Clifford H. Keen** has been named division sales manager of the Northeastern Division, with offices in New York City; **Fred T. Campbell** of the Southeastern Division with headquarters at Richmond; and **Frank D. Gibson** of the Atlantic Division, in Philadelphia. **Virgil E. Lown** has been appointed district manager at Salt Lake City, and **A. C. Mowery** district manager at Portland, Ore.

The Lamp Division of Westinghouse Electric Corp. announces the appointment of two staff assistants to managers. **Edward L. Ogden** has been named staff assistant to the manager of manufacturing, and **Eugene J. Murray** is staff assistant to the manager of Division operations. Both men will have their offices at the Lamp Division headquarters in Bloomfield.

Century Lighting, Inc., announces the formation of its new Color Lighting Department, and has appointed **Rollo Gillespie Williams** as Manager. The new department will pursue research and development in light sources, color media, quality and control. Mr. Williams, who has had 25 years of experience in color, is the author of two books, the most recent being *Lighting for Color and Form*.

John F. Myers, vice-president of the Westinghouse Electric Corp., has been appointed general manager of the company's marketing subsidiary, the Westinghouse Electric Supply Co. He takes over from **Victor D. Kniss,** who recently resigned as President. Mr. Myers will also continue his duties as vice-president of the parent company.

Pittsburgh Reflector Co. has announced recent additions in its southern states territories. **David S. Young** Co. will cover the Mid-Gulf area from new quarters at 328 Chartres St., New Orleans. Assisting Mr. Young will be **Louis S. Harris.** In the southwest territory the company has expanded the coverage of **Howard E. Johnson** of the Dallas sales office to include the entire states of Texas and Oklahoma.

(Continued on page 50A)

I.E.S. National Technical Conferences

1957 — September 9-13 — Biltmore Hotel, Atlanta, Georgia

1958 — August 17-22 — Royal York Hotel, Toronto, Ontario

1959 — September 7-11 — Hotels Fairmont and Mark Hopkins, San Francisco, California

"DECIDEDLY BETTER"

DAY-BRITE

Lighting Fixtures

DAY-BRITE LIGHTING MAKES THE BIG DIFFERENCE HERE

Lifetime lighting for modern hospitals

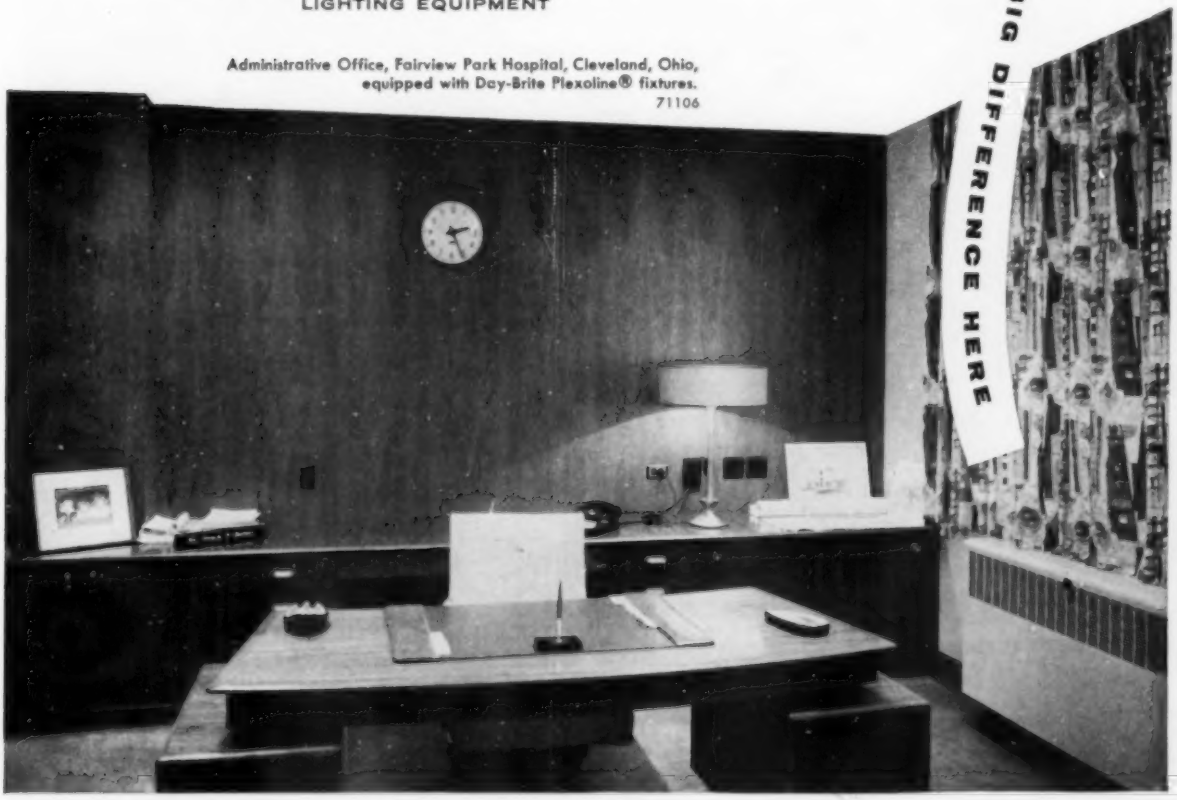
The wise course to follow when thinking of hospital lighting or relighting is to consider it as a long-term investment. This suggests a close table-top examination of fixture features, since all fixtures look good and sound good on paper.

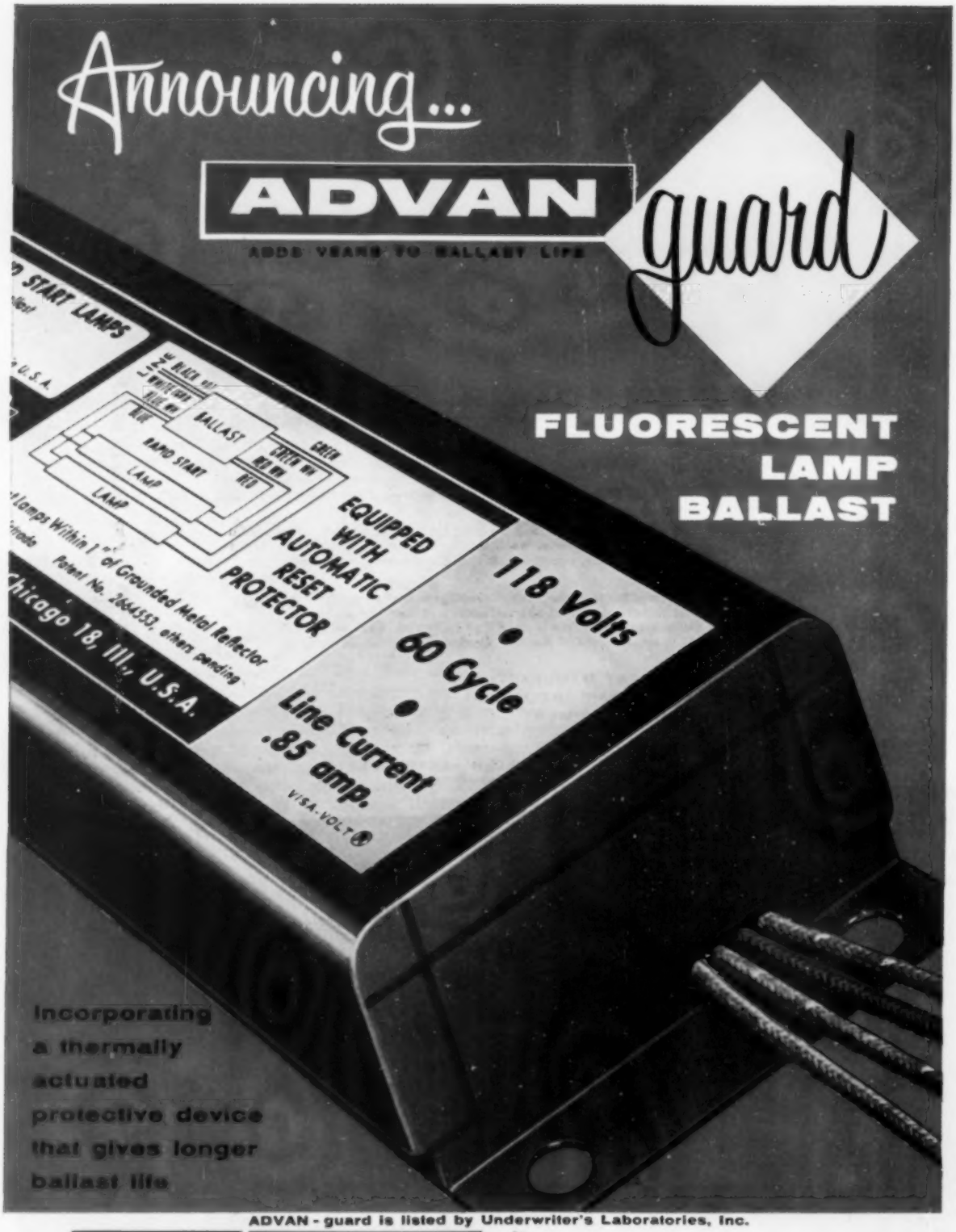
Day-Brite fixtures are designed and built to last. Application ranges from floor to ceiling—reception areas, waiting rooms, corridors, administration offices, patients' bedrooms, nurses' stations, pharmacies, kitchens, cafeterias, libraries.

For your own investment protection, investigate and compare Day-Brite with any other fixture. Look at the fixtures, not just the pictures. Your Day-Brite representative is ready to help you. *Call him . . .*
Day-Brite Lighting, Inc., 5432 Bulwer Avenue, St. Louis, Missouri.

NATION'S LARGEST MANUFACTURER
OF COMMERCIAL AND INDUSTRIAL
LIGHTING EQUIPMENT

Administrative Office, Fairview Park Hospital, Cleveland, Ohio, equipped with Day-Brite Plexoline® fixtures.
71106





ADVAN - guard is listed by Underwriter's Laboratories, Inc.

ADVANCE TRANSFORMER CO.

The Heart of the Lighting Industry

. . . the first major development in ballast design since the introduction of the fluorescent lamp . . .

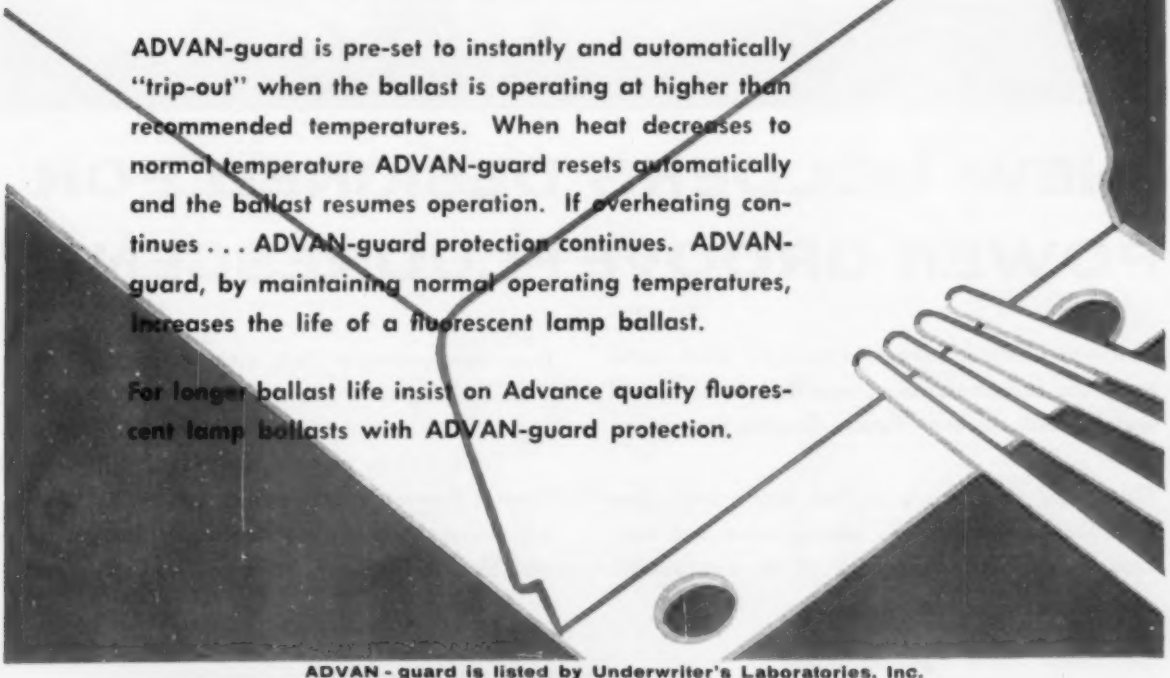
ADVAN guard

ADDS YEARS TO BALLAST LIFE

ADVAN-guard, an integral part of the new Advance Ballast design, adds years to ballast life by preventing ballast operation at abnormal temperatures. ADVAN-guard protects against excessive voltage supply . . . internal ballast short circuiting . . . inadequate lamp maintenance . . . improper fixture application . . . and eliminates the need for individual fixture fusing.

ADVAN-guard is pre-set to instantly and automatically "trip-out" when the ballast is operating at higher than recommended temperatures. When heat decreases to normal temperature ADVAN-guard resets automatically and the ballast resumes operation. If overheating continues . . . ADVAN-guard protection continues. ADVAN-guard, by maintaining normal operating temperatures, increases the life of a fluorescent lamp ballast.

For longer ballast life insist on Advance quality fluorescent lamp ballasts with ADVAN-guard protection.



ADVAN-guard is listed by Underwriter's Laboratories, Inc.

ADVANCE TRANSFORMER CO.

World's Largest Exclusive Manufacturer of Fluorescent Lamp Ballasts

2950 NO. WESTERN AVE. CHICAGO 18, ILL. U.S.A.

The Heart of the Lighting Industry

RAPID-START
COMPRESSIBLE
Rated at 600 volts-660 watts. Designed to accept T17 envelope and give shortest back-to-back spacing for Power-Groove Lamps. ALF 822 series.
RAPID-START
TELESCOPIC
Rated 600 volts-660 watts. ALF 812 series. Design of this holder provides proper clearance from mounting area for the larger diameter of Power-Groove Lamps.

NEW HOLDERS DESIGNED FOR POWER-GROOVE FLUORESCENTS

General Electric offers telescopic and compressible lampholders compatible in size and weight with the new Power-Groove Lamps

The rugged construction of these new holders gives them greater strength than existing units. Yet minimum back-to-back dimensions of the compressible type sharply reduce dark area. Both units feature double wiping silver-plated contacts adequate for new, higher lamp currents. See illustrations for details.

Information on this new family of General Electric fluorescent lampholders can be obtained by addressing Accessory Equipment Department, General Electric Company, Bridgeport 2, Connecticut.

Progress Is Our Most Important Product

GENERAL ELECTRIC

COMMITTEE PERSONNEL

COMMITTEES 1956-1957

All committees are appointed by the President, subject to approval of the Council and, except as provided in the Constitution, terminate at the time of the first Council meeting each administration, in the month of October. The scope of each committee is indicated.

M. N. Waterman, President, ex-officio member of all committees.

STANDING COMMITTEES

COUNCIL EXECUTIVE—To conduct the affairs of the Society between Council meetings.

M. N. Waterman, Chairman, Westinghouse Electric Corp., Bloomfield, N. J.

J. B. Browder	R. G. Slauer
K. M. Reid	G. J. Taylor

BOARD OF FELLOWS—To evaluate the eligibility of candidates for transfer to grade of Fellow according to procedures approved by the Council.

R. M. Evans, Chairman, Eastman Kodak Co., 65 Kodak Park, Rochester 4, N. Y.

Albert H. Clarke	Roy A. Palmer
R. M. Love	Edward Rambusch

George E. Shoemaker

FINANCE—To have direct supervision of the financial affairs of the Society and to present to the Council an annual report on its financial condition. To make recommendations to the Council as to the investment of moneys and upon all specific appropriations. To prepare and submit for approval of Council not later than the October meeting a budget of income and expense for the ensuing fiscal year.

W. P. Lowell, Jr., Chairman, Sylvania Electric Products, Inc., Salem, Mass.

W. W. Booth	C. C. Keller
J. B. Browder, ex-officio	R. M. Zabel

GENERAL BOARD OF EXAMINERS—To investigate the qualifications of all applicants for admission to membership; to elect or reject applicants for the grade of Associate Member and Student Member, to report such action to the Council; and to make recommendation to the Council regarding applications for transfer or election to the grade of Member or Retired member, and for transfer to the grade of Member Emeritus.

Svend W. Bruun, Chairman, 420 Lexington Ave., New York 17, N. Y.

H. E. D'Andrade	Ralph MacVean

MEDAL AWARD—To evaluate the eligibility of candidates for award of the I.E.S. Medal according to procedures approved by the Council.

Berlon C. Cooper, Chairman, McGraw-Hill Publishing Co., 330 W. 42nd St., New York 18, N. Y.

Julius Daniels	D. M. Jones
C. H. Goddard	Hoyt P. Steele
R. F. Hartenstein	E. M. Strong
B. J. Jensen	L. E. Tayler

PAPERS—To procure, review and approve all technical papers and discussions thereof, for presentation before National Conferences of the Society.

H. F. Davidson, Chairman, Curtis Lighting of Canada, Ltd., 195 Wickstead Ave., Leaside, Toronto, Ont.

B. S. Benson, Vice-Chairman, Benjamin Electric Mfg. Co., Des Plaines, Ill.

L. E. Barbrow	Floyd W. Sell
F. C. Breckenridge	G. A. Trosper
Kurt Franck	H. L. Wright
S. K. Guth	R. M. Zabel

PUBLICATIONS—To be responsible for the procurement, review and approval of all material for the publications of the Society other than technical papers approved by the Papers Committee for presentation at National Conferences of the Society and their discussions and committee reports, for which it will have publication responsibility only. Shall also be responsible for the editing, printing and business management of the publications of the Society; specific exceptions may be made by Council.

J. S. Schuchert, Chairman, Duquesne Light Co., 435 Sixth Avenue., Pittsburgh 19, Pa.

Brooks Chassaing	H. F. Davidson
J. R. Chambers	R. W. Morris

R. M. Zabel

GENERAL COMMITTEES

ADVANCE PLANNING—To study the operation, program, publication activities, membership classifications and financial structure with a view of its immediate and long-range objectives and to make recommendations to Council.

F. C. Winkler, Chairman, Westinghouse Electric Corp., 1216 W. 58th St., Cleveland 1, Ohio.

Vice-Chairman, A. C. Sangster, The Detroit Edison Co., 2000 Second Ave., Detroit, Mich.

G. W. Beals	A. B. Oday
A. H. Clarke	Glenn E. Park
B. J. Jensen	L. C. Twichell
W. P. Lowell, Jr.	R. M. Zabel

ADVISORY BOARD TO THE PRESIDENT—To examine the organization, accomplishments, and assignments of committees and prepare not later than July 1 of each year a proposed list of committees and personnel; and to evaluate costs and benefits of present and proposed Society services.

Kirk M. Reid, Chairman, General Electric Co., Nela Park, Cleveland 12, Ohio.

G. W. Beals	A. D. Hinckley
C. L. Crouch	G. J. Taylor
R. F. Hartenstein	F. C. Winkler

ALLIED ARTS—To encourage and assist local competitions in allied arts, in cooperation with technical committees and interested local groups.

Karl A. Staley, Chairman, General Electric Co., Nela Park, Cleveland 12, Ohio.

C. A. Atherton	Kenneth Parsons
R. W. Brown	Arthur J. Pulos
Eugene Frost	R. C. Putnam
A. B. Gallion	W. D. Riddle
J. H. Jensen	Harry E. Rodman
T. J. Killian	J. A. Russell
M. E. Lien	Foster K. Sampson
Onnie Mankki	Laurence Schmeckebier
T. W. Mackesey	H. M. Sharp
R. B. McFarland	G. E. Shoemaker
Joseph Morbito	J. S. Walsh
Roy Palmer	J. D. Whitnell

BOARD OF NOMINATION—To prepare a nomination ticket containing the names of those who are deemed best suited to serve as officers and directors in positions to be filled at the ensuing election.

E. M. Strong, Chairman, Cornell University, Ithaca, N. Y.

R. F. Hartenstein	D. M. Jones

CONSTITUTION AND BY-LAWS—To prepare for Council proposed amendments to the Constitution.

G. F. Dean, Chairman, Toronto Hydro-Electric System, 14 Carlton St., Toronto, Ont.

Arvid S. Almryde	Walter Sturrock
J. B. Browder	L. C. Twichell

DEFENSE COORDINATING—To contact various Government Agencies concerned with National Security suggesting cooperation and participation in specific projects as an aid to solution of their problems. Recommending the placement of lighting study projects in present committees or the appointment of study project committees to the Society President and to expedite such study projects and guide accepted reports into proper Government Channels.

J. W. Bateman, Co-Chairman, Canadian General Electric Co., Ltd., 212 King St., W., Toronto, Ont.

A. F. Wakefield, Co-Chairman, The Wakefield Co., Vermilion, Ohio.

H. R. Blackwell	C. L. Crouch
R. B. Brown, Jr.	K. M. Reid
O. P. Cleaver	John S. Walsh

HISTORICAL—To assemble and make available for current reference and to prepare in suitable and durable form for posterity, such historical facts, printed memorabilia, photographs, voice records, museum specimens and allied items as may be judged worthy of composing a continuing digest of the record of the Society's history.

S. G. Hibben, Chairman, 31 Clinton Avenue, Montclair, N. J.

J. L. Stair, Vice-Chairman, Ridgeland Apt Hotel, 1734 East 72nd St., Chicago 49, Ill

R. B. Burton, Sr.	Leo Dolkart
James Cravath	C. A. B. Halvorson
Julius Daniels	H. L. Logan

G. H. Stickney

LIGHTING SERVICE—To stimulate and promote the discussion and practical application of lighting recommendations and to conduct a Lighting Service Forum in connection with the National Technical Conference.

L. E. Tayler, Chairman, The Detroit Edison Co., 2000 Second Ave., Detroit 26, Mich.

C. W. McCormick, Vice-Chairman, Connecticut Light & Power Co., P. O. Box 2010, Hartford, Conn.

C. J. Berry	Carter Lewis
J. R. Chambers	T. C. Sargent

J. Thomas

MEMBERSHIP—To develop plans and supervise the operation of the individual membership activity of the Society.

Brooks Chassaing, Day-Brite Lighting Inc., 5411 Bulwer Ave., St. Louis 7, Mo.

C. L. Amick	T. W. Lauer
R. M. Johannesen	Gerald Marks

M. J. Myers, Jr.

NATIONAL TECHNICAL CONFERENCE—To be completely responsible, subject to the approval of Council, for the general coordination

(*Continued on page* 22A)

(*Continued from page* 21A)

of all conference activities, for selecting and recommending time and place for review of the plans and budgets of the National Technical Conference Executive Committee and in cooperation with the Papers Committee for the satisfactory time allocation for the Technical Papers sessions, according to Procedures and Policies as adopted by Council.

J. C. Forbes, Chairman, General Electric Co., Nela Park, Cleveland 12, Ohio.

C. L. Amick, Vice-Chairman, Day-Brite Lighting Inc., 5411 Bulwer Ave., St. Louis, Mo.

J. W. Bateman	J. D. Mitchell
R. B. Brown, Jr.	A. C. Sangster
J. B. Browder	J. S. Schuchert
H. F. Davidson	C. C. Shotwell
Clare K. Fulton	L. E. Tayler
A. D. Hinckley	Joseph Thomas
C. N. Laupp	Carlton M. Thompson
W. P. Lowell, Jr.	John S. Walsh

1957 Conference Executive Committee

J. B. Browder, Jr., Chairman, Georgia Power Co., 75 Marietta St., N. W., Atlanta 1, Ga.

Emily Alexander	Judd Lough
A. E. Bruner	J. D. Mitchell
Jack Burns	Fern Moran
Mary Bush	Jack Murrah
Cecil Cannon	Taylor Peake
Rita Kuzell	J. E. Sweatte

PROCEDURES AND POLICIES—To study problems of Society procedure and policy referred to the Committee by Council, and to formulate recommendations to Council for the statement, revision, or clarification of these procedures and policies consistent with the Constitution and By-Laws of the Society.

G. W. Beals, Chairman, The Miller Co., Meriden, Conn.

Brooks Chassaing	A. C. Sangster
G. F. Dean	L. C. Twichell
C. W. McCormick	John S. Walsh
	F. C. Winkler

PUBLIC RELATIONS AND INFORMATION — To prepare and disseminate information about the activities, accomplishments, programs, objectives and policies of the Society and about the place of illuminating engineering in modern society; to formulate and submit public relations policies and plans for the Society.

J. R. Chambers, Chairman, Benjamin Electric Manufacturing Co., Des Plaines, Ill.

B. C. Cooper	S. H. Hazleton
Herb Cornell	T. W. Lauer
W. A. Dalrymple	C. C. Shotwell
E. H. Gallet	J. F. Whitehead, Jr.

REGIONAL ACTIVITIES — To represent the respective Regions before the Council and to keep the Council informed regarding the affairs of the Regions. To stimulate Society activities, to encourage joint meetings of Sections and Chapters including Regional Conferences within the respective Regions, and to promote the expansion of the Society.

George J. Taylor, Chairman, Day-Brite Lighting, Inc., 161 East 42nd St., New York 17, N. Y.

John G. Felton, Jr.	E. M. Taylor
J. Dixon Mitchell	Joseph Thomas
George L. Morris	C. M. Thompson
Kenneth Reid	C. E. Waldron
J. A. Schneller	Nelson C. Warner
	J. D. Whitnell

RESIDENCE LIGHTING FORUMS — To stimulate and assist the Residence Lighting Forums of the Society and to encourage the formation of additional Forums. To conduct a Residence Lighting Forum in connection with the National Technical Conference.

Ruth Morris, Chairman, Georgia Power Co., P. O. Box 1719, Atlanta 1, Ga.

Anita Benson	Katharine Goodall
Nelson Bleisch	B. Martin
S. L. Burnham	J. Reynolds
Jack Burns	O. J. Scodock
Lillian Eddy	Virginia Skinner
Eve Freyer	Marion Seitz
Lloyd Gabler	Virginia Wells

SUSTAINING MEMBERSHIP—To develop plans and supervise the operation of the Sustaining Membership activity in the Society according to the Procedures and Policies adopted by Council.

Fred E. Guth, Chairman, The Edwin F. Guth Co., 2615 Washington Ave., St. Louis 3, Mo.

Brooks Chassaing	C. C. Shotwell
	G. J. Taylor

TRUSTEES, I.E.S. HEADQUARTERS RETIREMENT PENSION PLAN

D. M. Jones, Chairman, Curtis Lighting of Canada, Ltd., 991 St. Antoine St., Montreal, Que.

J. B. Browder	R. F. Hartenstein
	W. P. Lowell, Jr.

TASK COMMITTEES

I.E.S. - U. S. PUBLIC HEALTH SERVICE — To outline a method of making a survey of the visual factors of the working environment and the workers' vision and evaluating the findings in terms of visual comfort and effectiveness and eye health.

J. F. Parsons, Chairman, Niagara Mohawk Power Corp., Electric Bldg., Buffalo, N. Y.

B. S. Benson, Jr.	Henry N. Doyle
Mrs. Tula Brocard	Neal Jacobus
L. J. Cahill	A. L. Koven
George Clayton	R. P. Teele

TASK COMMITTEE ON SIGN LIGHTING — To study the lighting of signs, both exterior and interior and report thereon.

C. N. Laupp, Chairman, Wisconsin Electric Power Co., 231 W. Michigan St., Milwaukee, Wis.

B. S. Benson, Jr.	A. L. Hart
R. E. Faucett	W. H. Kahler
H. B. Fletcher	R. J. Neu

TECHNICAL COMMITTEES

AVIATION — To study the application of light and lighting to the spaces and functions involved in the operation of aircraft.

L. C. Simpson, Chairman, AGA Division, Elastic Stop Nut Corp. of America, 1737 H St., N. W., Washington 6, D. C.

P. H. Greenlee, Secretary, Grimes Mfg. Co., Urbana, Ohio.

R. J. Stefany, Treasurer, Westinghouse Electric Corp., Bloomfield, N. J.

J. F. Angier	R. R. Hilton
F. C. Ashe	W. D. Howell
F. B. Brady	J. P. Hoxie
F. C. Breckenridge	W. A. Jensen
J. M. Chamberlain	G. M. Kevern
P. B. Clark	C. B. King
G. K. Clement	M. K. Laufer
Don Coggins	A. L. Lewis
H. A. Cramer	D. C. Miller
W. A. Darrah	W. A. Pennow
C. A. Douglas	T. H. Projector
Peter Downey	F. C. Shipley
I. Fagin	R. A. Stone
O. F. Farris	L. C. Vipond
W. C. Fisher	T. C. Walker
J. S. Haney	M. A. Warskow
	J. P. Wilson

Aircraft Exterior Lighting

Capt. R. A. Stone, Chairman, Airline Pilots Assn., 55th St. & Cicero Ave., Chicago 88, Ill.

Aircraft Instrument Lighting

T. O. Twist, Chairman, National Bureau of Standards, Washington 25, D. C.

Airport Runway Lighting

C. A. Douglas, Chairman, National Bureau of Standards, Washington 25, D. C.

Airport Service Area Lighting

E. B. Karns, Chairman, Westinghouse Electric Corp., 1216 W. 58th St., Cleveland, Ohio.

Airport Taxiway Lighting

L. C. Vipond, Chairman, Office of Airports, CAA, Washington 25, D. C.

Approach Lighting

O. F. Farris, Chairman, Office of Federal Airways, CAA, Washington 25, D. C.

Aviation Lamps (Large)

R. J. Stefany, Chairman, Westinghouse Electric Corp., Bloomfield, N. J.

Aviation Lamps (Miniature)

D. C. Miller, Chairman, General Electric Co., Nela Park, Cleveland, Ohio.

Heliport Lighting

V. E. Converse, Chairman, Port of N. Y. Authority, 111 Eighth Ave., New York, N. Y.

Seadrome Lighting

A. L. Lewis, Chairman, Bureau of Aeronautics, Dept. of the Navy, Washington 25, D. C.

Definitions and Terms

J. F. Angier, Chairman, 14 Valley View Ave., Washington 12, D. C.

Papers

F. C. Breckenridge, Chairman, National Bureau of Standards, Washington 25, D. C.

Liaison Committeemen

P. B. Clark	J. S. Haney
W. C. Fisher	M. K. Laufer

COLOR — To study, evaluate and report on the effect of color in relation to the art and science of illumination.

DAYLIGHTING — To study the problems involved in daylighting, develop recommended practices and report thereon.

H. B. Vincent, Chairman, Owens-Illinois Glass Co., 1700 N. Westwood Ave., Toledo, Ohio.

J. W. Griffith, Vice Chairman, Southern Methodist Univ., Dept. of Engineering Res., Dallas, Texas.

W. J. Arner	E. M. Linforth
L. E. Barbrow	W. F. Little
R. A. Boyd	T. H. MacDonald
R. L. Biesele, Jr.	H. E. Machamer
A. A. Brainerd	Murray McDavitt
H. S. Bull	R. W. McKinley
E. W. Conover	E. C. Miles
Doyt Early	F. W. Mowrey
W. B. Ewing	R. H. Reed
C. D. Gibson	F. K. Sampson
B. F. Greene	Paul W. Seagers
J. S. Herbert	D. E. Spencer
G. N. Hingston	K. C. Welch
R. C. Kendall	O. F. Wenzler
H. F. Kingsbury	C. J. Youngblood

Availability of Daylight (Ext.)

B. F. Greene, Chairman, 100 W. 42nd Street, New York, N. Y.

R. A. Boyd	J. W. Griffith
	H. F. Kingsbury

Brightness Ratio Measurement

J. W. Griffith, Chairman, Southern Methodist University, Dept. of Engineering Research, Dallas, Texas.

W. J. Arner	E. W. Conover
R. A. Boyd	M. McDavitt
	E. C. Miles

Coordinating

R. A. Boyd, Chairman, Research Engineering Institute, University of Michigan, Ann Arbor, Mich.

E. M. Linforth	R. W. McKinley
	D. E. Spencer

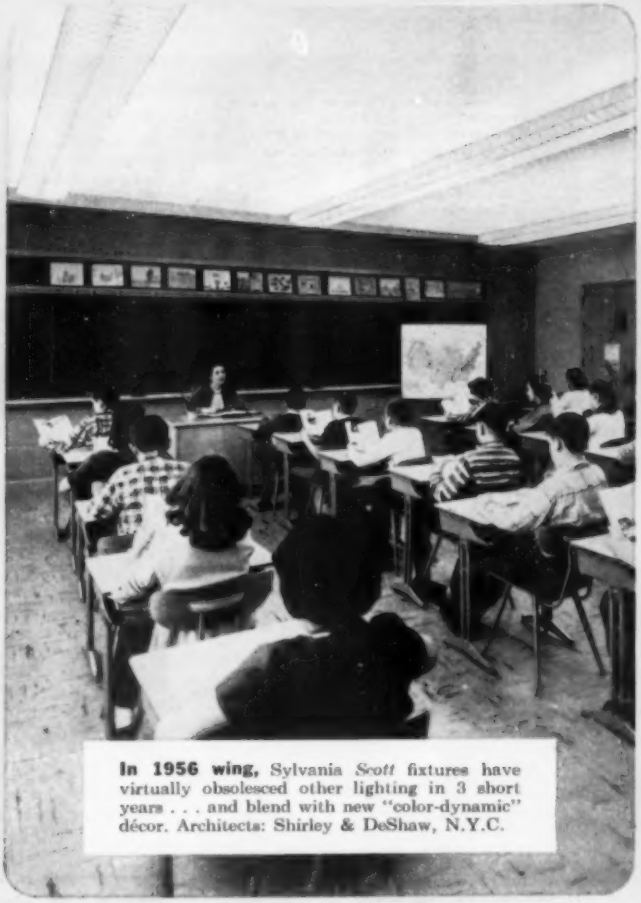
Lower Ceiling Classrooms

H. F. Kingsbury, Chairman, Research Department, Pittsburgh Corning Corporation, Port Allegany, Pa.

C. J. Allen	R. V. Hall
J. W. Griffith	C. A. Winkelhake

(*Continued on page* 24A)

In 1953 wing, Blauvelt (N.Y.) School installed conventional fluorescent fixtures—at that time considered modern and efficient—in their new classrooms.



In 1956 wing, Sylvania *Scott* fixtures have virtually obsolesced other lighting in 3 short years . . . and blend with new "color-dynamic" décor. Architects: Shirley & DeShaw, N.Y.C.

THE BLAUVELT SCHOOL STORY...

Higher efficiency of Sylvania Scott fixture makes big differences you can see

Greater quantities of light . . . better controlled illumination. This is the modern lighting job that Sylvania's *Scott* fixture delivers in the Blauvelt (N.Y.) School's new 13-room addition.

The Scott's eye-rest green tint blends with walls and furnishings in these *color-dynamic* classrooms. Students like the whole effect . . . see better . . . work better. And taxpayers are pleased to get this better looking, better performing school lighting with no increase in budget.

The Scott by Sylvania has a one-piece molded plastic reflector-shield which gently diffuses light and protects young eyes from direct lamp glare. Result is a pleasant "flood" of soft over-all illumination with high footcandle levels at desk top. Brightness and contrast ratios on ceilings and walls set new standards for eye comfort.

For expert assistance with your lighting problems, be sure to talk to the Sylvania Fixture Specialist in your area. And write today for your *free* copy of our helpful booklet, *"Some Whys and Hows of Modern School Lighting."*

SYLVANIA ELECTRIC PRODUCTS INC.
Dept. D30, Lighting Division—Fixtures
One 48th Street, Wheeling, W. Va.

Convenient hinging arrangement. The *Scott's* one-piece plastic shielding swings down from either side for easy maintenance—can be removed quickly for cleaning and lamp changes.

SYLVANIA

fastest growing name in sight

LIGHTING • RADIO • ELECTRONICS • TELEVISION • ATOMIC ENERGY

(*Continued from page* 22A)

Measurement and Reporting on Daylighting of Interiors
J. W. Griffith, Chairman, Dept. of Engineering Research, Southern Methodist University, Dallas, Texas.

J. S. Herbert	R. H. Reed
E. M. Linforth	D. E. Spencer

Revision of Handbook Daylighting Section
H. F. Kingsbury, Chairman, Pittsburgh Corning Corp., Port Allegany, Pa.

W. B. Ewing	E. M. Linforth
J. S. Herbert	R. W. McKinley

Revision of Recommended Practice for Daylighting
R. W. McKinley, Chairman, Product Development Dept., Pittsburgh Plate Glass Co., 1 Gateway Center, Pittsburgh 22, Pa.

W. J. Arner	R. C. Kendall
E. W. Conover	H. F. Kingsbury
W. B. Ewing	E. M. Linforth
B. F. Greene	T. H. MacDonald
R. M. Hanes	F. W. Mowrey
J. S. Herbert	C. J. Youngblood

DESIGN PRACTICE — To study published data on coefficients of utilization, room indexes, maintenance coefficients and other elements entering into calculations for lighting design; develop standard methods for use in Society publications and report thereon.
B. S. Benson, Jr., Chairman, Benjamin Electric Mfg. Co., Des Plaines, Ill.
W. M. Potter, Vice-Chairman, General Electric Co., Nela Park, Cleveland 12, Ohio.

G. W. Clark	N. T. Kridel
Ward Harrison	J. J. Neidhart
J. R. Jones	E. H. Salter
J. O. Kraehenbuehl	R. S. Wiseman

EDUCATION — To prepare educational and training programs on the fundamentals of illumination, lighting design problems and advance theories of light and lighting application. To prepare required text material and to further their adoption locally.
H. H. Magdsick, Chairman, 15925 Van Aken Blvd., Cleveland 20, Ohio.
R. S. Wiseman, Vice-Chairman, Engineer Research & Development Laboratories, Fort Belvoir, Va.

R. L. Biesele, Jr.	R. W. McKinley
L. H. Brown	J. F. Parsons
Oscar Cleaver	R. C. Putnam
D. M. Finch	E. M. Strong
W. A. Hedrich	D. E. Trefry
Harry Horn	I. A. Yost

C. W. Zersen

Brochure on Careers in Illuminating Engineering
R. S. Wiseman, Chairman, Research & Development Laboratories, Fort Belvoir, Va.
D. M. Finch — R. W. McKinley
E. M. Strong

Revise I.E.S. Courses on Lighting Fundamentals and Design
C. W. Zersen, Chairman, Chicago Lighting Institute, 140 So. Dearborn St., Chicago, Ill.

Robert Allen	J. M. Ketch
B. F. Avery	R. R. Lusk
A. M. Bacalar	Gerald Marks
B. S. Benson	J. F. Parsons
L. E. Innis	W. A. Weibel

R. E. Wozniak

FARM — To study the application of light and lighting of farm buildings, surrounding work areas and other rural locations and to report thereon.

HANDBOOK REVISION — To revise and arrange the technical content of the Handbook; to lay out, plan and arrange for development of individual sections primarily through appropriate technical committees; to consult with the Publications Committee on its presentation of a suitable publication budget for Council approval; to be responsible to Council for the accuracy and treatment of material including the format and paging.
J. J. Neidhart, Chairman, Miller Co., Meriden, Conn.

A. S. Almryde	W. H. Kahler
George Clark	R. W. Morris
Bruce Jensen	E. M. Strong

IES-ASHAE — (American Society Heating & Airconditioning Engineers) Joint Committee — To study the relationship between lighting and various factors that enter into the thermal environment and report thereon.
R. W. McKinley, Chairman, Pittsburgh Plate Glass Co., 1 Gateway Center, Pittsburgh 22, Pa.
Walter Sturrock

INDUSTRIAL — To initiate, follow up and coordinate lighting study projects in the industrial field, review the reports of the various subcommittees in this field and make recommendations to Council.
W. H. Kahler, Chairman, Westinghouse Electric Corp., 1216 W. 58th St., Cleveland 1, Ohio.

A. A. Brainerd	W. P. Lowell, Jr.
J. R. Chambers	Howard Long
Norman Kridel	D. J. O'Neill
E. A. Linsday	Leo G. Stahlhut

Central Station Properties
L. G. Parks, Jr., Chairman, Ebasco Services, Inc., 2 Rector St., New York, N. Y.

R. S. Bucher	E. A. Linsday
H. F. Carroll	Howard Long
H. A. Cook	D. J. O'Neill
R. W. Corwin	C. B. Stephens

Clothing
Norman Kridel, Chairman, Rochester Gas & Electric Co., 89 East Ave., Rochester, N. Y.

Leo Gauthier	L. C. Twichell
W. E. Hayes	Carl Uthe

Graphic Arts
Ralph Enghouser, Chairman, Sylvania Electric Products, Inc., 4700 Parkside Ave., Philadelphia, Pa.

Outdoor Production Areas
Elden H. Witte, Chairman, Benjamin Electric & Mfg. Co., Des Plaines, Ill.

Donald R. Brown	W. R. Preece, Jr.
Robert E. Faucett	Theodore Summers
D. J. O'Neill	A. G. Voelkner

W. W. Weld

Revision of Recommended Practice
E. A. Linsday, Chairman, General Electric Co., Nela Park, Cleveland, Ohio.

Sawmills
James Barnes, Chairman, Pacific Gas & Electric Co., P. O. Box 540, San Rafael, Calif.

INSTITUTIONS — To initiate, follow up and coordinate lighting study projects in the field of public buildings and private institutions, review the reports of the various study subcommittees in this field and make recommendations to Council.
Leonard V. James, Chairman, 513 S. Catherine Ave., LaGrange, Ill.

Berlon C. Cooper	C. N. Laupp

James H. McCulloch

Auditoriums and Churches
George Shoemaker, Chairman, Pennsylvania Power & Light Co., 1000 Chestnut St., Philadelphia, Pa.

Anthony L. Bleecker	T. Norman Mansell
John E. Flynn	A. C. Sangster

Henrik W. Olsen

Dining Areas
Carl W. Zersen, Chairman, Chicago Lighting Institute, Marquette Bldg., 140 S. Dearborn St., Chicago, Ill.

George Gilleard	E. L. Riego
C. T. Masterson	M. W. Ross
Eustace Mullins	Edward J. Wolff

Raymond Wozniak

Hotels
C. I. Sayles, Chairman, School of Hotel Administration, Cornell University, Ithaca, N. Y.

C. L. Cottrell	J. Fassett
H. E. D'Andrade	Francis Kealy
Myrtle Fahsbender	F. B. Mills

Theaters
Joel E. Rubin, Chairman, Kliegl Bros., 321 W. 50th St., New York 19, N. Y.

Alfred Boylen	G. T. Howard
T. W. Butler	Arthur C. Risser
Ariel Davis	H. D. Sellman
Theodore Fuchs	George Smedberg
Walter H. Garrett, Jr.	Rollo G. Williams

Hospitals
N. L. Griffin, Chairman, Federal Security Agency, Public Health Service, Washington 25, D. C.

H. W. Alexander	H. L. Logan
L. J. Buttolph	Paul Seagers
E. H. Greppin	Howard Sharp
Howard Haynes	Wm. H. Smith

Museums and Art Galleries
J. M. Ketch, Chairman, General Electric Co., Nela Park, Cleveland 12, Ohio.

Willard Thompson

LIGHT CONTROL & EQUIPMENT DESIGN — Collect and correlate the knowledge and data on means and methods of controlling, directing, reflecting, transmitting and diffusing light and on the principles and practices of equipment design.
Eric H. Church, Chairman, Lighting Products, Inc., 1549 Park Ave., W. Highland Park, Ill.
John T. McLaughlin, Vice-Chairman, Kelso-Burnett Electric Co., 223 W. Jackson Blvd., Chicago 6, Ill.

G. R. Baumgartner	Henry Peterson
Milton Buzan	Maurice E. Robertson
Clarence Clarkson	J. N. Robertson
C. M. Holden	Wm. Weibel
R. I. Nagel	F. C. Winkler
F. W. Ogden	Elden H. Witte

Plastics (IES-SPI-NEMA)
F. C. Winkler, Chairman, Westinghouse Electric Corp., 1216 W. 58th St., Cleveland, Ohio.

W. M. Bagley	W. P. Lowell, Jr.
J. S. Capps	C. O. Massopust
A. J. Dragonette	R. R. Moyer
W. J. Fitzgerald	C. Rackley
George Gilleard	E. Szantay
W. C. Goggin	G. P. Wakefield

H. A. Williams

LIGHT SOURCES — To correlate and report available information as to the physics of light and light production and the characteristics of current light sources.
E. H. Salter, Chairman, Electrical Testing Labs., Inc., 2 East End Ave. & 79th St., New York 21, N. Y.
George Freeman, Vice-Chairman, Westinghouse Electric Corp., Bloomfield, N. J.

Herbert Anderson	David Cutler
L. E. Barbrow	H. F. Davidson
W. P. Carpenter	R. B. Dull
R. D. Churchill	Walter Houston

E. F. Kelly

Color Rendition
Dorothy Nickerson, Chairman, 2039 New Hampshire Ave., N. W., Washington 9, D. C.

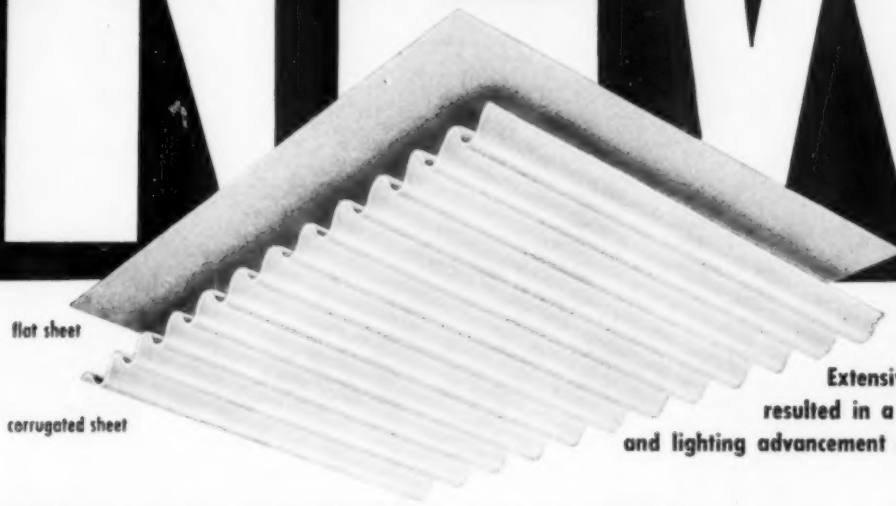
E. W. Beggs	Norman Macbeth
C. N. Clark	G. R. Stillwell
C. W. Jerome	Luke Thorington
D. B. Judd	Arthur Weeks

MAINTENANCE — To study the elements contributing to maintenance factors; set up the framework of typical field studies to determine factors; and to stimulate the prosecution of such studies by appropriate agencies.
Francis Clark, Chairman, Lighting Services, 515 Meridan Road, Waterbury, Conn.

R. D. Bradley	Howard Long
E. I. Creed	D. R. Philips
L. M. Endres	Bert C. Pretzer
R. R. Enghouser	James R. Rodisch
W. C. Fink	R. P. Teele
C. M. Holden	R. L. Zahour
M. E. Keck	E. I. Zastrow

(*Continued on page* 26A)

NEW



PATENT APPLIED FOR

Extensive research has now resulted in a combined acoustical and lighting advancement of great significance

SOUNDSHEET TRANSLUCENT ACOUSTICAL ELEMENT For Over-all Lighting Systems

For the first time, efficient *acoustical* properties have been combined with top quality illumination characteristics in a good-looking plastic laminate! Soundsheet by Contrex Company supplements other acoustical treatments, and can be effectively used with most wall-to-wall or area lighting systems now in existence or in the planning stage. Here are just a few advantages of Soundsheet:

- ★ **BALANCED SOUND ABSORPTION** — more at low frequencies than the average of commonly used types of acoustical treatment. Good absorption at the higher frequencies. N.R.C. — 0.70 by independent test for corrugated Soundsheet.
- ★ **QUALITY ILLUMINATION** — softly diffused lighting free of shadows and reflections at high efficiency.
- ★ **EASY TO INSTALL** — available in all standard widths; adaptable to most available over-all ceiling equipment, now installed or on order.
- ★ **AVAILABLE NOW** — in either corrugated or flat sheet — consult your lighting equipment manufacturer for use with his equipment.
- ★ **LOW COST** — initial and operating expenses — very little maintenance necessary — Soundsheet is completely washable.

Soundsheet harmonizes perfectly with any of today's architectural interior concepts. Contrex Company invites you to examine this new plastic laminate — Soundsheet — and learn more about its advantages and how they can benefit you.

Developed for Contrex by Bolt Beranek and Newman, Inc.

CONTREX

CONTREX COMPANY
CHELSEA 50, MASSACHUSETTS

MAIL TO:
CONTREX COMPANY
CHELSEA 50, MASS.

☐ Please send me literature and a sample of Soundsheet.

☐ Please have your representative call.

NAME_____

Company_____

ADDRESS_____

CITY_____ STATE_____

IE-4

(*Continued from page 24A*)

MOTOR VEHICLE (EXTERIOR) — To study the problems of illuminating the night operations of motor vehicles and to make suitable recommendations for promoting maximum safety and convenience including accessorry illuminated signal and traffic aids.

R. P. Teele, Chairman, National Bureau of Standards, Washington 25, D. C.

L. L. Beltz	D. M. Finch
P. J. Blinkilde	Burton Marsh
W. E. Carpenter	Charles Marsh
L. W. Chubb, Jr.	R. I. Nagel
Elliot F. Daniels	Edmund Ricker
Neil Dormstadter	Val Roper
R. N. Falge	A. Rugo

W. E. Schwanhausser

NOMENCLATURE — To define the terms and standards of illumination, and endeavor to obtain uniformity in nomenclature.

Priscilla Presbrey, Chairman, Westinghouse Electric Corp., Bloomfield, N. J.

E. Q. Adams	D. M. Finch
Abraham Abramowitz	S. K. Guth
George Clark	J. O. Kraehenbuehl
C. L. Cottrell	W. F. Little

Harris Reinhardt

OFFICE — To study the lighting requirements of office lighting tasks, develop suitable lighting recommendations and report thereon.

G. F. Dean, Chairman, Toronto Hydro-Electric System, 14 Carlton St., Toronto, Ont.

A. S. Almryde	R. W. McKinley
C. L. Amick	J. J. Neidhart
C. T. Bakeman	G. G. Rae
L. M. Endres	T. H. Shepherd
W. S. Fisher	R. T. Waite
W. E. Folsom	G. P. Wakefield
C. W. Macy	R. R. Wylie

R. L. Zahour

Handbook Revision

G. F. Dean, Chairman, Toronto Hydro-Electric System, 14 Carlton St., Toronto, Ont.

C. L. Amick	G. G. Rae
L. M. Endres	T. H. Shepherd
W. S. Fisher	R. R. Wylie

PROGRESS — To keep in touch with developments in the art of lighting throughout the world and prepare a yearly review of achievements in the art of illuminating engineering for inclusion in ILLUMINATING ENGINEERING.

J. H. McCulloch, Chairman, Independent Testing Labs., 1928 Fourteenth St., Boulder, Colo.

E. A. Linsday, Vice-Chairman, General Electric Co., Nela Park, Cleveland, Ohio.

R. C. Allison	John Gornet
H. A. Andersen	Arthur R. Jaeger
E. W. Beggs	W. S. Kolb
L. R. Bush	F. J. Marriett
J. T. Chambers	T. C. Sargent
O. P. Cleaver	R. V. Smith
R. E. Faucett	M. K. Strang
D. M. Finch	R. P. Teele
B. Goldberg	H. A. Williams

Frank E. Winslow

PUBLIC CONVEYANCES — INTERIOR LIGHTING — To study the application of light to all public areas in conveyances used for passenger transportation, including particularly trains, buses, ships, street railways and subways, and report thereon.

E. Boghosian, Chairman, Dept. of the Navy, Bureau of Ships, Code #350, Washington 25, D. C.

A. L. Arenberg	F. T. Snider
C. E. Egeler	J. B. Spillane
J. B. Feder	J. L. Swarner
E. B. Hallman	R. L. Sweeney
R. L. Henderson	R. M Timmins
T. S. Madonia	A. Vandevelde

W. C. Wheeler

Interior Lighting — Land Transportation

J. L. Swarner, Chairman, Pullman Standard Car Mfg. Co., 10909 Cottage Grove Ave., Chicago, Ill.

A. L. Arenberg	C. B. Mackay
J. S. Bauer	T. S. Madonia
R. H. Berts he	W. R. Preece, Jr.
W. N. Bodkin	G. L. Sealey
E. B. Hallman	F. T. Snider
R. L. Henderson	W. C. Wheeler

A. C. Zagotta

Marine Transportation

R. Timmins, Chairman, Gibbs & Cox, Inc., 21 West St., New York, N. Y.

W. M. Adrian	E. A. Geary
E. Boghosian	R. K. Johnson
Dean Farnsworth	T. S. Madonia
J. B. Feder	R. L. Sweeney
Frank Carlson	A. F. Vandevelde

RESIDENCE — To study and report on the application of light and lighting in residences; to develop performance recommendations for residence luminaires and to prepare necessary educational aids.

F. J. Marriett, Chairman, Thomas Industries, Inc., 410 S. Third St., Louisville 2, Ky.

W. Blitzer	L. Neuwirth
M. Fahsbender	Jan Reynolds
A. R. Jaeger	R. V. Smith
K. Leighton	Mary B. Tsepke
E. A. Meehan	Norman Vacha

Measurement of Performance Characteristics of Portable Lamps

R. V. Smith, Chairman, Holophane Co. Inc., 342 Madison Ave., New York, N. Y.

SCHOOL — To study the application of light and lighting to the spaces and processes involved in educational institutions and to report thereon.

J. M. Chorlton, Chairman, Board of Education, 155 College St., Toronto 2B, Ont.

Carl Allen, Secretary, General Electric Co., Nela Park, Cleveland 12, Ohio.

W. Allphin	Chester Jarrett
R. L. Biesele, Jr.	J. L. Kilpatrick
R. D. Bradley	C. N. Laupp
L. H. Brown	H. L. Logan
H. F. Davidson	J. D. MacConnell
A. A. Eastman	J. J. Neidhart
F. M. Foote	J. F. Parsons
W. V. C. Foulks	R. C. Putnam
R. L. Hamon	F. K. Sampson
D. B. Harmon	Paul Seagers
R. C. Hultgren	E. M. Strong
L. V. James	H. A. Stroud

K. C. Welch

Chalkboards

H. F. Davidson, Chairman, Curtis Lighting of Canada, Ltd., 195 Wickstead Ave., Leaside, Toronto, Ont.

Electrical Lighting Design

J. F. Parsons, Chairman, Niagara Mohawk Power Corp., Buffalo 2, N. Y.

Visual Problems

Paul Seagers, Chairman, School of Education, Indiana University, Blomington, Ind.

SEARCHLIGHT — To study the design and application of searchlights and to report thereon.

J. A. Bartelt, Chairman, Dept. of the Navy, Bureau of Aeronautics, Code EL-S 211, Washington 25, D. C.

W. A. Pennow, Vice-Chairman, Westinghouse Electric Corp., 1216 W. 58th St., Cleveland 1, Ohio.

Thomas W. Cushing, Secretary, Hanovia Chemical & Mfg. Co., Room 422, Washington Bldg., Washington, D. C.

Stewart Belden	E. B. Heyer
Ernest Boghosian	G. M. Kevern
F. E. Carlson	Harold Korbel
A. H. Clarke	J. P. Latil
Pierre Demoreuille	W. W. Lozier
C. E. Egeler	Peter Mole
R. E. Faucett	T. I. Monahan
B. R. Finch	J. Kirk Newell
George Gerung	L. R. Noffsinger
C. J. Glass	Don Petersen
D. S. Gustin	B. Pritchard
Robert Heine-Geldern	T. H. Projector
Arthur Hatch	S. Resnik
Charles A. Hearn	O. D. Wertz

Liaison Representative

J. C. Boggs	B. Goldberg
	C. H. Orr

Executive

J. A. Bartelt, Chairman, Dept. of the Navy, Bureau of Aeronautics, Code EL-S 211, Washington 25, D. C.

Ernest Boghosian	W. A. Pennow
T. W. Cushing	T. H. Projector

Bibliography

J. P. Latil, Chairman, Genarco Inc., 97-04 Sutphin Blvd., Jamaica, N. Y.

Light Sources

R. E. Faucett, Chairman, Engineering Research and Development Laboratories, Fort Belvoir, Va.

Stewart Belden	Harold Korbel
F. E. Carlson	J. P. Latil
George Gerung	W. W. Lozier
Arthur Hatch	C. H. Orr

S. M. Segal

Nomenclature

Ernest Boghosian, Chairman, Dept. of the Navy, Bureau of Ships, Code 560, Washington 25, D. C.

T. W. Cushing	H. Korbel

Optics

D. Petersen, Chairman, Bausch & Lomb Optical Co., Rochester, N. Y.

W. Drake	B. Goldberg
B. R. Finch	E. B. Heyer

A. W. Patteson

Revision of IES Handbook

T. H. Projector, Chairman, National Bureau of Standards, Washington 25, D. C.

J. A. Bartelt	A. E. Krawcek
Ernest Boghosian	L. F. Noffsinger
Sidney Feldman	S. M. Segal

Testing Procedures

T. H. Projector, Chairman, National Bureau of Standards, Washington 25, D. C.

A. H. Clarke	W. W. Lozier
Sidney Feldman	S. M. Segal
George Gerung	R. S. Wiseman

Visibility of Sources

W. A. Pennow, Chairman, Westinghouse Electric Corp., 1216 58th St., Cleveland 1, Ohio.

Visibility of Targets

L. R. Noffsinger, Chairman, National Bureau of Standards, Washington 25, D. C.

J. C. Boggs	A. W. Patteson
A. H. Clarke	H. C. Smith

SIGNAL LIGHTING, ELEMESTS OF — To compile a compendium of current information on all phases of signal lighting.

F. C. Breckenridge, Chairman, National Bureau of Standards, Washington 25, D. C.

J. A. Bartelt	H. J. C. Pearson
H. R. Blackwell	L. C. Simpson
G. M. Kevern	R. T. Tousey

J. W. Tuttle

SPORTS AND RECREATIONAL AREAS — To develop current recommended practices for lighting sports and recreational areas; study techniques of application including effects on player performance and spectator visibility and report thereon.

F. D. Wyatt, Chairman, 427 Cottage Hill Ave., Elmhurst, Ill.

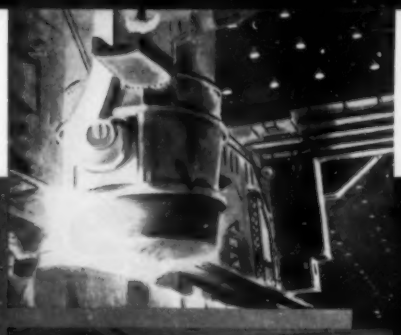
M. W. Ross, Secretary, Commonwealth Edison Co., 72 W. Adams St., Chicago 90, Ill.

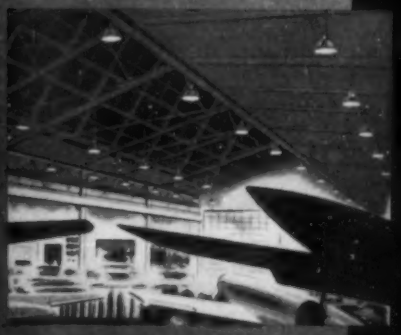
James Bale	W. P. Graham
J. W. Bateman	Howard Long
B. S. Benson, Jr.	Edward Machtinger
Donald R. Brown	John Mucha
R. H. Dickinson	D. E. Trefry
R. T. Dorsey	W. W. Weld
R. E. Faucett	H. M. White

(*Continued on page 29A*)

NEW! For Effective Lighting of High Mounting Areas...

HOLOPHANE HIBAY* Reflector For Mercury Vapor Lamps





Especially Recommended for:
Steel Mills
Foundries
Power Plants
Paper Mills
Machine Shops
Hangars
Armaries
Sports Arenas
Field Houses
Gymnasiums

No. 640

Holophane engineers, authorities in the development of lighting for industrial interiors, present another important contribution in this field —a new HIBAY Reflector... Designed for 400 Watt Mercury-vapor lamps... This unit consists of only two parts: (1) ventilated socket yoke; (2) smooth prismatic reflector with sealed metal cover. This simplified construction permits easy installation and economical maintenance. Reflector surface is kept clean by upward draft action induced by open design. Exposed socket assembly assures rated lamp life. Light source is deep-shielded, eliminating glare.

Write for complete engineering data on industrial lighting today.

The name HOLOPHANE is your Surest Guide to LIGHTING QUALITY

Every Holophane product is carefully and individually pressed on specialized equipment. Only by this painstaking process can we make prismatic forms accurate enough to direct light precisely where it is needed. Holophane products provide the basis for custom-engineered lighting systems, specifically designed for each area. To be sure of quality look for the name "HOLOPHANE" impressed on each piece.

HOLOPHANE

COMPANY, INC. • *Lighting Authorities Since 1898*

342 Madison Ave., New York 17, N.Y.

THE HOLOPHANE CO., LTD., 418 KIPLING AVE. SO., TORONTO 14, ONTARIO

Holophane *For Better Lighting...Be Specific*

HERE IT IS—

EXTRULITE® R1

PATTERNED CLEAR PLASTIC PANEL

- Offering superior low brightness
- Designed for the efficient control and transmission of light
- No waste—No cutting
- Lightweight and tough
- Eliminates breakage

Here is a new material developed for the modern "thin look" in fixtures. The ultimate in pleasant, glare-free low brightness lighting.

Extrulite R1 definitely increases the sales appeal of your fixture.

SPECIAL ORDERS Produced to Your Exact Size
Widths: from 6" to 24"
Thickness: from .100" to .187"
or any convenient shipping length
In Plexiglas®, Polystyrene, Butyrate, Lucite*

STOCK SIZE in Polystyrene or Acrylic
Available Immediately —
10¾" x 47½" x .125" (approx. weight 2 lbs.)

Write for sample and test report or for information on developing your own exclusive pattern by this unique process.

*DuPont Trade Mark

ROTUBA EXTRUDERS, INC.
418 88th STREET • BROOKLYN 9, NEW YORK
SHore Road 8-5458

Makers of
QUALITY PLASTIC EXTRUSIONS FOR INDUSTRY

Phila. Office
R. L. BOUSE, FLOURTOWN, PENNA.
Tel. CHESTNUT HILL 8-1010

(*Continued from page 26A*)

STANDARDS OF QUALITY AND QUANTITY FOR INTERIOR ILLUMINATION — To prepare standards for illumination levels, brightness limits, brightness ratios for interiors, including specific visual tasks, as well as the general surroundings.

Glenn A. Fry, Chairman, School of Optometry, Ohio State University, Columbus 10, Ohio.

W. Allphin — S. K. Guth
L. E. Barbrow — Ward Harrison
H. R. Blackwell — H. L. Logan
Dean Farnsworth — D. E. Spencer
E. M. Strong

STORE — To study the application of light and lighting to the spaces and processes involved in the selling of goods and to report thereon.

C. M. Cutler, Chairman, General Electric Co., Nela Park, Cleveland 12, Ohio.

Lester Geis, Vice-Chairman, Garden City Plating & Mfg. Co., 23 W. 47th St., New York, N. Y.

R. C. Allison — Richard Kelly
D. P. Caverly — J. J. Neidhart
L. H. Dickelman — G. G. Rae
W. H. Johnson — N. J. Sonnenfeld
K. C. Welch

Service Station and Parking Areas

E. H. Schaefer, Chairman, Wisconsin Electric Power Co., 231 W. Michigan St., Milwaukee 3, Wisc.

W. G. Barr — J. R. Fairweather
Fred Bayis — A. L. Hart
B. S. Benson — M. C. Harsh
D. B. Brown — M. E. Haskins
C. M. Cutler — Frank Lago
A. B. Winters

STREET AND HIGHWAY — To establish the scientific principles underlying street and highway lighting; to collect data on the results of the application of such principles to actual practice; to prepare such reports thereon as will assist technicians and benefit the public.

G. K. Glass, Chairman, Detroit Edison Co., 2000 Second Ave., Detroit 26, Mich.

D. W. Rowten, Vice-Chairman, Westinghouse Electric Corp., 1216 W. 58th St., Cleveland 1, Ohio.

T. Seburn, Secretary, Bureau of Highway Traffic, Strathcona Hall, Yale University, New Haven, Conn.

R. P. Brotzman — Charles R. Minors
R. S. Bucher — Fred E. Moesta, Jr.
Phillip B. Clark — A. T. Nadeau
Wilbur F. Crosby — J. J. Oberhausen
Warren Edman — O. P. Ortlieb
W. B. Elmer — H. W. Osborne
J. H. Fahey — R. J. Palmer
D. M. Finch — Ellis E. Paul
C. A. B. Halvorson — C. H. Rex
M. B. Hastings — L. J. Schrenk
W. Earle Hawkins — F. J. Schmitt
L. F. Heckmann — R. M. Swetland
R. M. Hoot — R. P. Teele
Harry Hrivnatz — D. A. Toenjes
M. E. Keck — G. A. Trosper
G. E. Korten — Arnold Vey
Albert Lorch — Harold E. Wall
Carl H. Lundell — A. B. Winters
R. B. Marxheimer — F. D. Wyatt
Harold Mason — R. R. Wylie
Roy W. Matthews — John W. Young
John F. McGough — R. M. Zabel

Coordination

G. E. Korten, Chairman, Consumers Power Co., 212 W. Michigan Ave., Jackson, Mich.

H. W. Osborne — G. A. Trosper

Fluorescent

R. M. Zabel, Chairman, Westinghouse Electric Corp., Bloomfield, N. J.

P. B. Clark — C. H. Rex
W. H. Edman — L. J. Schrenk
W. B. Elmer — D. A. Toenjes
A. T. Nadeau — H. E. Wall
H. S. Nonneman — R. R. Wylie

Handbook Revision

G. E. Korten, Chairman, Consumers Power Co., 212 W. Michigan Ave., Jackson, Mich.

Interchange with Foreign Groups

W. H. Edman, Chairman, Holophane Co., Newark, Ohio.

D. A. Toenjes — R. R. Wylie
R. M. Zabel

High Speed, Heavy Traffic Density Highways

P. B. Clark, Chairman, Line Material Co., East Stroudsburg, Pa.

M. E. Keck — C. H. Rex
O. P. Ortlieb — D. A. Toenjes
E. E. Paul — F. D. Wyatt
P. L. Young

Luminaire Maintenance

H. E. Wall, Chairman, 16249 LaSalle St., College Station, Detroit, Mich.

R. E. Ballard — C. A. Minors
H. S. Beagle — R. J. Palmer
R. P. Brotzman — E. Parks
L. Dolkart — K. L. Partridge
W. H. Dorman — W. S. Skove
H. A. Friede — G. A. Trosper
G. E. Korten — C. E. Waldron
A. T. Nadeau — G. A. Watters
J. F. McGough — F. D. Wyatt
J. W. Young

Mercury Vapor Lamp

J. W. Young, Chairman, New England Power Service Co., 441 Stuart St., Boston 16, Mass.

R. P. Brotzman — D. A. Toenjes
P. B. Clark — G. A. Trosper
H. E. Mason — H. E. Wall
F. E. Moesta — F. D. Wyatt
R. P. Teele — R. R. Wylie
R. M. Zabel

Parking Area Lighting

W. H. Edman, Chairman, Holophane Co., Inc., Newark, Ohio.

L. Dolkart — C. H. Rex
J. L. Eberly — F. J. Schmitt
M. E. Keck — R. M. Swetland
C. A. Minors — C. E. Waldron
O. P. Ortlieb — A. B. Winters
H. W. Osborne — J. W. Young

Pavement Surfaces

F. D. Wyatt, Chairman, 427 Cottage Hill Ave., Elmhurst, Ill.

H. S. Beagle — W. T. Lynch
D. M. Finch — H. S. Nonneman
T. W. Forbes — C. H. Rex
J. S. Franklin — L. J. Schrenk
H. A. Friede — W. S. Skove
C. A. B. Halvorson — D. A. Toenjes
L. F. Heckman — C. E. Waldron
L. M. Johnson — H. E. Wall

Photographic Studies

W. E. Hawkins, Chairman, Atlantic City Electric Co., 1600 Pacific Ave., Atlantic City, N. J.

R. S. Bucher — F. J. Schmitt
G. A. Eddy — R. P. Teele
J. F. McGough — D. A. Toenjes
F. Vaughn

Program and Publicity

L. F. Heckman, Chairman, The Union Metal Mfg. Co., 1432 Maple Ave., N. E., Canton 5, Ohio.

M. E. Keck — J. E. Sweatte
F. E. Moesta — G. A. Trosper
H. S. Nonneman — C. E. Waldron

Research

D. A. Toenjes, Chairman, General Electric Co., Nela Park, Cleveland 12, Ohio.

W. H. Dorman — R. P. Teele
W. B. Elmer — F. D. Wyatt
D. M. Finch — R. R. Wylie
T. W. Forbes — P. L. Young
C. H. Rex — R. M. Zabel

Roadway Lighting Principles

C. H. Rex, Chairman, Outdoor Lighting Dept., General Electric Co., Hendersonville, N. C.

P. B. Clark — M. E. Keck
W. H. Dorman — H. E. Wall
W. H. Edman — F. D. Wyatt
J. W. Young

Standard Practice

C. A. B. Halvorson, Chairman, 30 Red Rock St., East Lynn, Mass.

W. H. Edman — R. P. Teele
M. E. Keck — D. A. Toenjes
R. W. Matthews — G. A. Trosper
K. Partridge — H. E. Wall
C. H. Rex — F. D. Wyatt
R. M. Zabel

Traffic Safety

O. P. Ortlieb, Chairman, 311 Municipal Bldg., Trenton 8, N. J.

J. L. Eberly — H. W. Osborne
J. H. Fahey — K. L. Partridge
T. W. Forbes — F. J. Schmitt
L. Heckmann — R. M. Swetland
C. A. Minors — C. E. Waldron
R. W. Matthews — H. E. Wall

Traffic Signs

H. W. Osborne, Chairman, City of Buffalo, 1801 City Hall, Buffalo 2, N. Y.

J. L. Eberly — W. T. Lynch
T. W. Forbes — R. W. Matthews
H. A. Friede — C. W. Prisk
J. P. Hoxie — E. R. Ricker
Vern Waight

Tunnel and Underpass

R. M. Swetland, Chairman, General Electric Co., Outdoor Lighting Dept., Hendersonville, N. C.

M. E. Keck — F. J. Schmitt
H. E. Mason — G. A. Trosper
J. J. Oberhausen — D. A. Toenjes
H. W. Osborne — H. E. Wall

Visibility under Fog Conditions

Ellis E. Paul, Chairman, Howard, Needle, Tammen & Bergendoff, 55 Liberty St., New York 5, N. Y.

E. W. Boggs — G. Meese
P. B. Clark — C. W. Prisk
A. A. Eastman — C. H. Rex
W. H. Edman — E. R. Ricker
D. M. Finch — R. M. Swetland
J. P. Hoxie — R. P. Teele
A. R. Knight — D. A. Toenjes
C. H. Lundell — G. A. Trosper
C. R. Marsh — F. D. Wyatt
R. M. Zabel

TELEVISION — LIGHTING FOR PRODUCTION — To study and report on the lighting for production of television programs.

Walter O'Meara, Chairman, National Broadcasting Co., 30 Rockefeller Plaza, New York 20, N. Y.

TESTING PROCEDURES FOR ILLUMINATION CHARACTERISTICS — To prepare standard test procedures for illumination characteristics of light sources, lighting equipment and illumination materials, and to report thereon.

A. E. Krawcek, Chairman, Crouse-Hinds Co., Syracuse 1, N. Y.

Phelps Meaker, Vice-Chairman, General Electric Co., Nela Park, Cleveland 12, Ohio.

J. E. Bock — J. H. McCulloch
R. D. Bradley — George A. Meyers
D. M. Finch — F. M. Neal
Kurt Franck — Priscilla Presbrey
J. S. Franklin — D. W. Rowten
W. G. Hill — E. H. Salter
G. A. Horton — Floyd Sell
Paul Lamson — R. P. Teele
W. F. Jones — Maxwell Trostle
C. E. Leberknight — A. W. Weeks
T. H. Leister — E. H. Witte

General Guide to Photometry

R. P. Teele, Chairman, National Bureau of Standards, Washington 25, D. C.

W. F. Jones

Guide for Brightness Measurements

Paul H. Lamson, Chairman, Smithcraft Lighting Div., 217 Everett, Chelsea 50, Mass.

R. D. Bradley — A. E. Krawcek
D. M. Finch — J. H. McCulloch
G. A. Horton — E. H. Salter
W. F. Jones — R. P. Teele
E. H. Witte

(*Continued on page 34A*)

I. E. S. National and Local Officers—1956-1957

Officers and Council 1956-1957

President — M. N. WATERMAN, Westinghouse Electric Corp., Bloomfield, N. J.

Vice-President — KIRK M. REID, General Electric Co., Nela Park, Cleveland, Ohio.

Vice-President — GEORGE J. TAYLOR, Day-Brite Lighting, Inc., 161 E. 42nd St., New York, N. Y.

Past-President — DUNCAN M. JONES, Curtis Lighting Co. of Canada, Ltd., 991 St. Antoine Street, Montreal, Que.

Past-President — R. F. HARTENSTEIN, Ohio Edison Co., Akron, Ohio.

General Secretary — R. G. SLAUER, Sylvania Electric Products Inc., Wheeling, West Va.

Treasurer — J. B. BROWDER, Georgia Power Co., 75 Marietta St., N. W., Atlanta 1, Ga.

Directors

BROOKS CHASSAING, Day-Brite Lighting Inc., 5411 Bulwer St., St. Louis 7, Mo.

G. F. DEAN, Toronto Hydro Electric System, 14 Carlton St., Toronto, Ont.

C. W. MCCORMICK, Connecticut Light & Power Co., P. O. Box 2010, Hartford 1, Conn.

A. C. SANGSTER, The Detroit Edison Co., 2000 Second Ave., Detroit 26, Mich.

L. C. TWICHELL, Rochester Gas & Electric Corp., 89 East Ave., Rochester 4, N. Y.

JOHN S. WALSH, Pacific Gas & Electric Co., 245 Market St., San Francisco 6, Calif.

Regional Vice-Presidents

Canadian Region — JOSEPH THOMAS, Canadian General Electric Co., Ltd., 280 Faillon St. W., Montreal, Que.

East Central Region — NELSON C. WARNER, Westinghouse Electric Corp., 306 Fourth Ave., Pittsburgh 30, Pa.

Great Lakes Region — R. M. TAYLOR, The Toledo Edison Co., 420 Madison Ave., Toledo, Ohio.

Inter-Mountain Region — J. D. WHITNELL, Arizona Public Service Co., P. O. Box 2591, Phoenix, Ariz.

Midwestern Region — JOSEPH A. SCHNELLER, Lighting Products, Inc., 1549 Park Ave., N., Highland Park, Ill.

Northeastern Region — C. E. WALDRON, Niagara Mohawk Power Corp., 126 State St., Albany, N. Y.

Pacific Northwest Region — KENNETH REID, Corp. of the City of Victoria, City Hall, Victoria, B. C.

South Central Region — GEORGE L. MORRIS, Alabama Power Co., 600 N. 18th St., Birmingham 2, Ala.

South Pacific Coast Region — CARLTON M. THOMPSON, San Diego Gas & Electric Co., P. O. Box 1831, San Diego 12, Calif.

Southeastern Region — J. DIXON MITCHELL, Westinghouse Electric Corp., 2260 Peachtree Industrial Blvd., Chamblee, Ga.

Southwestern Region — JOHN G. FELTON, JR., Sylvania Electric Products, Inc., 100 Fordyce St., Dallas, Texas.

Section and Chapter Officers 1956-1957

Alabama Section — South Central Region

Chairman — JOHN T. KEYSER, JR., Alabama Power Co., 2100 N. 1st Ave., Birmingham, Ala.

Secretary — W. C. MARTIN, JR., Alabama Power Co., 2100 1st Ave. N., Birmingham, Ala.

Alamo Chapter — Southwestern Region

Chairman — R. G. TURPIN, 627 Marchmont, San Antonio, Texas.

Secretary — JACK C. FAGLIE, Box 7246 Hackbury Station, San Antonio, Texas.

Arizona Section — Inter-Mountain Region

Chairman — JOHN F. GOHRING, J. E. Redmond Supply Co., 625 W. Madison, Phoenix, Ariz.

Secretary — ROBERT E. TWEEDY, 914 W. Madison St., Phoenix, Ariz.

Arkansas Chapter — South Central Region

Chairman — VOLNEY O. RISER, Westinghouse Electric Corp., Roosevelt Road, Little Rock, Ark.

Secretary — JAMES C. VENABLE, Associated Manufacturers Agents, 5218 Hawthorne Road, Little Rock, Ark.

Ark-La-Tex Chapter — Southwestern Region

Chairman — CLIFFORD HAM, General Electric Co., 1513 Line Avenue, Shreveport, La.

Secretary — JOHN BOWEN, 139 Justin, Shreveport, La.

Bluenose Chapter — Canadian Region

Chairman — A. W. EVANS, Province of Nova Scotia, Dept. of Highways, Halifax, N. S.

Secretary — K. WILKINSON, Northern Electric Co. Lt., Halifax, N. S.

British Columbia Section — Pacific Northwest Region

Chairman — D. S. GORDON, B. C. Electric Co. Ltd., 570 Dunsmuir St., Vancouver, B. C.

Secretary — A. ANDERSON, British Columbia Electric Railway Co., 570 Dunsmuir St., Vancouver 2, B. C.

Capital Section — East Central Region

Chairman — HAROLD V. OERTING, Potomac Electric Power Co., 10th & E Sts. N. W., Washington 4, D. C.

Secretary — A. J. RUGO, Sylvania Electric Products Inc., 2520 Oakville St., Alexandria, Va.

Central Illinois Chapter — Midwestern Region

Chairman — R. WEIMAN, Associated Engineers, 1100 First National Bank, Peoria, Ill.

Secretary — DEL SCHNEIDER, Central Illinois Light Co., 316-318 S. Jefferson, Peoria, Ill.

Central New York Section — Great Lakes Region

Chairman — E. L. MOYER, Malcolm B. & Edwin L. Moyer, Box 21, Calvin Station, Syracuse 5, N. Y.

Secretary — J. S. HANEY, Crouse-Hinds Co., 1201 Wall St., Syracuse 1, N. Y.

Central Oklahoma Chapter — Southwestern Region

Chairman — CHARLES E. DAVIS, 2624 N. W. 47th St., Oklahoma City, Okla.

Secretary — LLOYD BOYLES, Oklahoma Gas & Electric Co., 321 N. Harvey, Oklahoma City, Okla.

Chicago Section — Midwestern Region

Chairman — ERIC H. CHURCH, Lighting Products Inc., 1549 Park Avenue, W., Highland Park, Ill.

Secretary — JOHN J. MCLAUGHLIN, Kelso Burnett Electric Co., 223 W. Jackson Blvd., Chicago 6, Ill.

Chinook Chapter — Pacific Northwest Region

Chairman — DON FROST, Amalgamated Electric Corp. Ltd., 1025 11th Ave. W., Calgary, Alta.

Secretary — DONALD LITTLE, City of Calgary Electric Light Dept., 115 6th Ave. W., Calgary, Alta.

Cleveland Section — Great Lakes Region

Chairman — M. E. KECK, Westinghouse Electric Corp., 1216 W. 58th St., Cleveland 1, Ohio.

Secretary — C. J. ALLEN, General Electric Co., Nela Park, Cleveland 12, Ohio.

Connecticut Section — Northeastern Region

Chairman — MERRITT HORNER, 815 Chestnut Hill Road, Glastonbury, Conn.

Secretary — WILLIAM P. CARPENTER, The Superior Electric Co., 83 Laurel St., Bristol, Conn.

Cornhusker Section — Midwestern Region

Chairman — FORD BATES, Omaha Public Power District, 718 Electric Bldg, Omaha 2, Nebr.

Secretary — WILLIAM J. COOK, Omaha Public Power District, 174 Harvey Sts., Omaha, Nebr.

Eastern New York Section — Northeastern Region

Chairman — C. D. HOLLISTER, Niagara Mohawk Power Corp., 126 State St., Albany 1, N. Y.

Secretary — DONALD W. GOODWIN, Havens Electric Co., 31 Hudson Ave., Albany, N. Y.

Eastern Pennsylvania Section — East Central Region

Electric Corp., 739 Hamilton St., Allentown, Pa.

Secretary — R. J. PRETZMAN, Raub Supply Co., James & Mulberry St., Lancaster, Pa.

Edmonton Chapter — Pacific Northwest Region

Chairman — R. C. B. JARVIS, Jarvis & Co., 10546 - 109 Street, Edmonton, Alta.

Secretary — FRED R. DORWARD, Canadian General Electric Co. Inc., 513 Northern Hardware Bldg., Edmonton, Alta.

Florida Section — Southeastern Region

Chairman — GEORGE N. JACK, Raybro Electric Supplies Inc., P. O. Box 370, St. Petersburg, Fla.

Secretary — GORDON L. FRIDAY, 4318 Renellie Dr., Tampa, Fla.

Georgia Section — Southeastern Region

Chairman — W. M. PEARSON, Graybar Electric Co., 333 North Ave., N. W., Atlanta 1, Ga.

Secretary — THOMAS W. HASLAM, Georgia Power Co., 75 Marietta St., N. W., Atlanta, Ga.

Golden Gate Section — South Pacific Coast Region

Chairman — GUY DELEUIL, 221 Oak St., San Francisco 2, Calif.

Secretary — JOHN E. KEYES, Benjamin Electric Mfg. Co., 829 Folsom St., San Francisco 7, Calif.

(*Continued on page* 33A)

Kopp *Flying Glassware*

keeps pace with expanding air travel

"Can we depend on the glass?"

You certainly can when it's Kopp Glass. That's because Kopp is specifically designed and custom-made to provide optimum dependability and safety under the most severe service conditions.

Kopp "flying" glassware is carefully engineered to give you the best in beam control, color transmission, weather resistance and any other desirable characteristic. An excellent service record both on airplanes and on airports has been the result.

But Kopp engineers aren't resting on these achievements. They're pressing forward relentlessly—piercing safety barriers—to improve existing products and develop new ones. Call today if you have a technical glass problem. Our engineering department will be glad to help you.

KOPP GLASS

KOPP GLASS, Inc.

Swissvale, Pennsylvania

A "Blue Chip" INVESTMENT BY 3 of Philadelphia's Largest Banks

they bought **metco Lighting**

GIRARD TRUST CORN EXCHANGE BANK

Specially designed METCO 2-lamp troffers with curved prismatic Holophane® lens light this bank's center-city skyscraper offices. Extra-shallow unit — only 2⅞" overall recessing depth — was developed to meet air conditioning requirements.

Designers and Constructors: United Engineers & Constructors Inc
Electrical Contractor: H. B. Frazer & Co., Inc.

THE PHILADELPHIA NATIONAL BANK

Special 2 x 4 METCO troffers with hinged Corning #70 low brightness lens lights this corridor in bank's headquarters building.

Architects: Harbeson, Hough, Livingston & Larson
Consulting Engineers: Stewart A. Jellett Co.
Electrical Contractor: Cates & Shepard

FIDELITY-PHILADELPHIA TRUST COMPANY

Standard METCO "AURORA" troffers and "ASTRA-LITE" pendant luminaires were used in this bank's downtown offices.

Designed and Installed by J. A. Green,
Chief Electrical Engineer, Fidelity-Philadelphia Trust Company

Certified Lighting for a Better America

Sold only through qualified electrical distributors

METALCRAFT PRODUCTS COMPANY, INC., Mascher and Lippincott Streets, Philadelphia 33, Pa.

(*Continued from page 30A*)

Hamilton Ontario Chapter — Canadian Region

Chairman—JOHN H. MILLS, Chadwick-Carroll Brass & Fixture Ltd., 365 Wilson St., Hamilton, Ont.

Secretary — E. K. MORWICK, Canadian Westinghouse Co., Ltd., Aberdeen Ave., Hamilton, Ont.

Heart of America Section — Midwestern Region

Chairman — F. E. MILES, Frank Miles Electric Co., 821 W. 17th St., Kansas City 8, Mo.

Secretary — T. C. SIDLO, General Electric Co., 200-210 E. 16th Ave., N. Kansas City 16, Mo.

Indiana Section — Midwestern Region

Chairman — DENTON E. HALL, C. M. Buck & Assoc., 2927 Central Ave., Indianapolis 5, Ind.

Secretary — HARRY W. CLAFFEY, JR., General Electric Co., 1115 Circle Tower Bldg., Indianapolis, Ind.

Inland Empire Chapter — Pacific Northwest Region

Chairman — GEORGE E. ROMANS, Washington Water Power Co., W. 825 Trent Ave., Spokane 10, Wash.

Secretary — TED BEADLE, Washington Water Power Co., P. O. Drawer 1445, Spokane 10, Wash.

Iowa Section — Midwestern Region

Chairman — GALE L. WILLIAMS, Iowa Public Service Company, P. O. Box 600, Waterloo, Iowa.

Secretary — WILLIAM J. VAHL, Crescent Electric Supply Co., 200 S. Main St., Dubuque, Iowa.

Maritime Chapter — Canadian Region

Chairman — DOUGLAS MACMACKIN, 98 Wright St., St. John, N. B.

Secretary — LESLIE MACKIE, Curtis Lighting Inc., P. O. Box 824, Saint John, N. B.

Maryland Section — East Central Region

Chairman — C. EDWARD SPARROW, JR., Westinghouse Electric Corp., 501 St. Paul Place, Baltimore, Md.

Secretary — PAUL J. PUCKETT, Westinghouse Electric Corp., 501 St. Paul Place, Baltimore 2, Md.

Mexico Chapter

Chairman — SABANO ESCOBEDO G., F. Montes de Oca #38, Mexico 11, D. F.

Secretary — ARNO KOSAK, Donceles 89, Mexico 1, D. F.

Miami Valley Chapter — Great Lakes Region

Chairman — D. R. HUGHES, JR., 121 Forrer Rd., Dayton, Ohio.

Secretary — JOHN F. MCKEAND, c/o Gerald R. Helmig & Associates, 357 W. 1st St., Dayton, Ohio.

Michigan Section — Great Lakes Region

Chairman — HARRY R. ROBBINS, General Electric Co., 1400 Book Tower, Detroit 26, Mich.

Secretary — JAMES F. FINN, The Detroit Edison Co., 2000 Second Ave., Detroit, Mich.

Mid-South Chapter — South Central Region

Chairman — H. F. COLLINS, JR., General Electric Co., 1179 Morehead St., Memphis, Tenn.

Secretary — HAROLD G. MCMULLEN, Memphis Light, Gas & Water Division, 179 Madison Ave., Memphis, Tenn.

Milwaukee Section — Midwestern Region

Chairman — WALLAAM N. LISCH, Lisch Electric Co., 1125 N. 3rd St., Milwaukee 3, Wis.

Secretary — M. H. BREUSEWITZ, Wisconsin Electric Power Co., 231 W. Michigan St., Milwaukee 1, Wis.

Mississippi Chapter — South Central Region

Chairman — R. E. COPE, Box 4263, Fondren Station, Jackson 6, Miss.

Secretary — C. P. HAYNES, Watts Electric Co., 227 S. Farish St., Jackson, Miss.

Montreal Section — Canadian Region

Chairman — J. P. R. CRISTEL, The Shawinigan Water & Power Co., 600 Dorchester St. W., Montreal, Que.

Secretary — GORDON NAKO, Mitchell Mfg. Co., Ltd., 3600 Barclay St., Montreal, Que.

Mother Lode Chapter — South Pacific Coast Region

Chairman — MELVERN P. FENTON, Smoot-Holman Co., 1331 T., Sacramento 14, Calif.

Secretary — CHARLES A. DEAN, JR., Pacific Gas & Electric Co., 1100 "K" St., Sacramento 6, Calif.

New England Section — Northeastern Region

Chairman — CARLETON M. HOLDEN, Champion Lamp Works, 330 Lynnway, Lynn, Mass.

Secretary — RALPH L. HUSE, Holophane Co. Inc., 39 Kingston St., Boston, Mass.

New Mexico Chapter — Inter-Mountain Region

Chairman — ROBERT J. UHL, 6026 Princess Jeanne, Albuquerque, N. M.

Secretary — JOSEPH J. LOPEZ, 1622 Coal Ave. S. W., Albuquerque, N. M.

New Orleans Section—South Central Region

Chairman — S. C. BERDON, New Orleans Public Service Inc., 317 Baronne St., New Orleans 12, La.

Secretary — C. C. KLEINSCHMIDT, P. O. Box 843, New Orleans, La.

New York Section — Northeastern Region

Chairman — G. G. RAE, Holophane Co. Inc., 342 Madison Avenue, New York, N. Y.

Secretary — R. L. ZAHOUR, Westinghouse Electric Corp., Bloomfield, N. J.

Northwestern Ohio Section — Great Lakes Region

Chairman — ROBERT COLGAN, Rogers Electrical Service Inc., 527 Conrad, Toledo 7, Ohio.

Secretary — H. W. TEEL, JR., Toledo Edison Co., Edison Bldg., Toledo 4, Ohio.

Ohio Valley Section — Great Lakes Region

Chairman — V. G. MCCLUSKY, General Electric Co., 36 E. 4th St., Cincinnati 2, Ohio.

Secretary — FRED B. MACRAE, 6914 Montgomery Road, Cincinnati 36, Ohio.

Oil Capital Section — Southwestern Region

Chairman — F. ALLEN WHITESIDE, Black & West Architects, 205 Tri State Insurance Bldg., Tulsa 3, Okla.

Secretary — JAMES C. NETHERTON, JR., 3130 E. 44th St., Tulsa, Okla.

Oregon Section — Pacific Northwest Region

Chairman — D. E. SEELY, Westinghouse Electric Corp., U. S. National Bank Bldg., Portland, Ore.

Secretary — JOHN A. SCHULTER, Sunbeam Lighting Co., 411 Weatherly Bldg., Portland 14, Ore.

Ottawa Chapter — Canadian Region

Chairman—J. RYLANCE, Directorate of Works (Army), Dept. of National Defense, "C" Bldg., Ottawa, Ont.

Secretary — W. FULTON, Northern Electric Co. Ltd., 141 Catherine St., Ottawa, Ont.

Palmetto Chapter — Southeastern Region

Chairman — R. NEAL CAMPBELL, Campbell Leppard, Box 3353, Station A, Greenville, S. C.

Secretary — JAMES W. WHITE, Duke Power Co., 1199 Washington St., Greenville, S. C.

Panhandle Chapter — Southwestern Region

Chairman — THOMAS J. LYNN, Southwestern Public Service Co., P. O. Box 1261, Amarillo, Texas.

Secretary — HAROLD W. POWELL, Broome Electric Co. Inc., 2700 Lincoln, Amarillo, Texas.

Philadelphia Section — East Central Region

Chairman — WILLIAM R. MACKINNEY, Rumsey Electric Co., 1232 Hamilton St., Philadelphia, Pa.

Secretary — ROBERT L. HERR, Philadelphia Electric Co., 1000 Chestnut St., Philadelphia, Pa.

Pittsburgh Section — East Central Region

Chairman — JAMES P. BOYDEN, JR., Westinghouse Electric Corp., 306 Fourth Ave., Pittsburgh 30, Pa.

Secretary — J. S. FRIZZELL, Pittsburgh Reflector Co., 403 Oliver Bldg., Pittsburgh 22, Pa.

Puget Sound Section — Pacific Northwest Region

Chairman — HOWARD C. HALL, 405 Union, Seattle 1, Wash.

Secretary — JACK H. WELLS, B. T. Heinz Co., 1500 Westlake N., Seattle 9, Wash.

Quebec Chapter — Canadian Region

Chairman — G. DUBEAU, Northern Electric Co., 1299 Charest Blvd., Quebec, Que.

Secretary — H. R. PAYSON, Tri-Bec, Inc., Industrial Centre #5, Quebec, Que.

Rochester Section — Great Lakes Region

Chairman — R. BRUCE THOMPSON, 9 Laconia Parkway, Rochester 14, N. Y.

Secretary — MISS MELROSE M. FRANKLIN, Rochester Gas & Electric Co., 89 East Ave., Rochester 4, N. Y.

Rocky Mountain Section — Inter-Mountain Region

Chairman — LEONARD J. CARLON, Albert Sechrist Mfg. Co., 4990 Acoma, Denver 16, Colo.

Secretary — LEIGH CONGDON, Rite Lite Supply Co., 1218 Galapago St., Denver 4, Colo.

St. Louis Section — Midwestern Region

Chairman — ROBERT J. WELCH, R. J. Welch Co., 3903 Olive St., St. Louis 8, Mo.

Secretary — CHARLES H. ZURHEIDE, Smith-Harlon-Zurheide-Levy, Inc., 3926 Lendell Blvd., St. Louis 8, Mo.

San Diego Chapter — South Pacific Coast Region

Chairman — G. S. KIMBALL, San Diego Gas & Electric Co., P. O. Box 1831, San Diego, Calif.

Secretary — R. W. ROHRBACK, Pacific Wholesale Electric Co., 702 State St., San Diego 12, Calif.

(*Continued on page 34A*)

Committee Personnel

(*Continued from page 29A*)

Guide for Electrical Measurements of Fluorescent Lamps
George A. Meyers, Chairman, Sylvania Electric Products, Inc., 75 Sylvan Street, Danvers, Mass.

Guide for Electrical Measurements of Mercury Vapor Lamps
J. S. Franklin, Chairman, General Electric Co., Hendersonville, N. C.

Guide for Life Performance Testing of Fluorescent Lamps
Priscilla Presbrey, Chairman, Westinghouse Electric Corp., Bloomfield, N. J.

Guide for Outdoor Illumination Tests
G. A. Horton, Chairman, Westinghouse Electric Corp., 1216 W. 58th St., Cleveland, Ohio.

Guide for Photometric Measurements of Mercury Vapor Lamps
J. S. Franklin, Chairman, General Electric Co., Hendersonville, N. C.

M. H. Gabriel — P. Presbrey
F. M. Neal — E. H. Salter
J. H. Park — A. W. Weeks
J. W. Young

Guide for Photometric Testing of Floodlights of 10-160° Beam Spread
J. S. Franklin, Chairman, General Electric Co., Hendersonville, N. C.

G. A. Horton — A. E. Krawcek
Elden H. Witte

Guide for Photometric Testing of Fluorescent Lamps
A. W. Weeks, Chairman, Champion Lamp Works, 330 Lynnway, Lynn, Mass.

W. G. Hill — G. A. Meyers
W. F. Jones — E. H. Salter

Guide for Photometric Testing of Fluorescent Luminaires
G. A. Horton, Chairman, Westinghouse Electric Corp., 1216 W. 58th St., Cleveland, Ohio.

R. D. Bradley — W. M. Potter
D. M. Finch — E. H. Salter
P. H. Lamson — Ruland Smith
F. M. Neal — Maxwell Trostle
E. H. Witte

Guide for Photometric Testing of Outdoor Fluorescent Luminaires
J. S. Franklin, Chairman, General Electric Co., Hendersonville, N. C.

J. E. Bock — G. A. Horton
T. H. Leister

Guide for Photometry of Searchlights
A. E. Krawcek, Chairman, Crouse Hinds Co., Syracuse 1, N. Y.

J. E. Bock — J. S. Franklin

Guide for Reporting Lighting Equipment Engineering Data
E. H. Witte, Chairman, Benjamin Electric Mfg. Co., Des Plaines, Ill.

R. D. Burnham — J. H. McCulloch
R. P. Teele

Guide for Use of Photoelectric Portable Photometers
G. A. Horton, Chairman, Westinghouse Electric Corp., 1216 W. 58th St., Cleveland, Ohio.

Guide on Colorimetry
R. P. Teele, Chairman, National Bureau of Standards, Washington 25, D. C.

M. H. Gabriel — C. E. Leberknight
W. H. Houston — A. W. Weeks

Local Officers

(*Continued from page 33A*)

San Jacinto Section — Southwestern Region

Chairman — CURT W. GREVELIUS, Warren Electric Co., 2112 Walker Avenue, Houston, Texas.

Secretary — RICHARD C. JUNG, General Electric Co., 807 C & I Life Bldg., Houston 2, Texas.

San Jose Chapter — South Pacific Coast Region

Chairman — GEORGE BAKER, Pacific Gas & Electric Co., 86 S. 3rd St., San Jose 14, Calif.

Secretary — DON WARFIELD, General Electric Co., 999 98th Ave., Oakland 3, Calif.

Southeast Florida Chapter — Southeastern Region

Chairman—J. V. SHELLHORSE, Florida Power & Light Co., 25 S. E. 2nd Ave., Miami 30, Fla.

Secretary — FRED WILLIAM MARKLAND, Graybar Electric Co., 2111 N. W. 22nd Ave., Miami, Fla.

Southern California Section — South Pacific Coast Region

Chairman — GEORGE A. HOCHENAUER, Benjamin Electric Mfg. Co., 923 E. Third St., Los Angeles 13, Calif.

Secretary — AUDIE ASHCRAFT, Southern California Edison Co., 601 W. 5th St., Los Angeles, Calif.

Southern Colorado Chapter — Inter-Mountain Region

Chairman — ROBERT F. EVEN, Southern Colorado Power Co., 115 W. 2nd St., Pueblo, Colo.

Secretary — LESTER B. JOHNSON, Pueblo Electric Supply Co., 131 Spring St., Pueblo, Colo.

Southwestern Section — Southwestern Region

Chairman — JOHN B. DECK, JR., Texas Power & Light Co., P. O. Box 6331, Dallas 2, Texas.

Secretary — E. L. COLE, Dallas Power & Light Co., 1506 Commerce, Dallas 1, Texas.

Suwanee River Chapter — Southeastern Region

Chairman — A. H. BRUNING, Georgia Power Co., Valdosta, Ga.

Secretary — ARTHUR T. CRABTREE, Union Electric Supply Co., 207 W. Hill Ave., Valdosta, Ga.

Tar Heel Section — Southeastern Region

Chairman — A. L. DUCKER, JR., General Electric Co., Greensboro, N. C.

Secretary — JAMES A. LOWE, Duke Power Co., Drawer K-1, Greensboro, N. C.

Tennessee Valley Section — South Central Region

Chairman — JOE W. FOWLER, Joe Willis Factory Sales Agency, 601 Fifth Ave., Nashville, Tenn.

Secretary — HARRY W. BOURGEOIS, 1805 Harjes St., Nashville 4, Tenn.

Toronto Section — Canadian Region

Chairman — GRANT E. DAVIDSON, Hydro Electric Power Commission, 620 University Ave., Toronto, Ont.

Secretary—E. MACHTINGER, Crouse-Hinds Co. of Canada Ltd., 7-21 Labatt Ave., Toronto, Ont.

Twin City Section — Midwestern Region

Chairman — A. A. ARONSON, Northern States Power Co., 15 S. Fifth St., Minneapolis, Minn.

Secretary — F. T. TILLEMANS, Westinghouse Electric Corp., 2303 Kennedy St., N. E., Minneapolis 13, Minn.

Twin Ports Chapter — Midwestern Region

Chairman — KENNETH PETERSON, Westinghouse Electric Corp., 100 Elizabeth St., Duluth, Minn.

Secretary — ERIC G. NYLUND, Nylund Electric Co., 5723 Grand Ave., Duluth 7, Minn.

Utah Section — Inter-Mountain Region

Chairman — WAYNE F. MULCOCK, Utah Power & Light Co., 138 S. Main St., Salt Lake City 10, Utah.

Secretary — EARL DON PETERSON, Utah Power & Light Co., 138 S. Main St., Salt Lake City 10, Utah.

Vancouver Island Chapter — Pacific Northwest Region

Chairman — A. S. HARRIS, B. C. Electric Co., 820 Pendora Ave., Victoria, B. C.

Secretary — WALTER E. BEEK, B. C. Electric Co., 1501 Douglas St., Victoria, B. C.

Virginia Chapter — East Central Region

Chairman — D. N. JENKS, General Electric Co., 1004 N. Thompson St., Richmond 21, Va.

Secretary — T. P. HARRIS, 6037 Bonneau Road, Richmond 27, Va.

Western Michigan Section — Great Lakes Region

Chairman — W. DALE CRITES, 1377 Biscayne Way, Haslett, Mich.

Secretary — WILLIAM WINGLAR, J & G Doremman Co., 924 Grandville Ave., Grand Rapids 2, Mich.

Western New York Section — Great Lakes Region

Chairman — BYRON F. LYTH, JR., Niagara Mohawk Power Corp., 535 Washington St., Buffalo 3, N. Y.

Secretary — LEO P. GAUTHIER, Sylvania Electric Products Inc., 407 Jackson Bldg., Buffalo 2, N. Y.

Winnipeg Chapter — Canadian Region

Chairman — D. J. BOURDON, Amalgamated Electric Corp. Ltd., 677 Notre Dame Ave., Winnipeg, Man.

Secretary — M. SPIGELMAN, City of Winnipeg, Hydro Electric System, 55 Princess St., Winnipeg, Man.

Yankee Chapter — Northeastern Region

Chairman — ARTHUR C. BRODEUR, JR., Western Massachusetts Electric Co., 65 State St., Springfield, Mass.

Secretary — BARTHOLOMEW D. BARRY, JR., Western Mass. Electric Co., Springfield, Mass.

Down to Earth

Here's a "down to earth" fact. From base details to pole tops, Monotube street lighting poles are engineered to the highest standards of quality, appearance and performance. No compromise!

You are assured of satisfaction *and* economy both today *and* "tomorrow".

For catalogs or specific engineering data, write to The Union Metal Manufacturing Company, Canton 5, Ohio.

UNION METAL

Monotube Lighting Poles

Fixtures for the new National Housing Center, Washington, D.C., by Smithcraft Lighting Division, Chelsea, Massachusetts. LUCITE molded by Mack Molding Company, Arlington, Vermont. Architects: Aubinoe, Edwards and Beery, Washington, D.C. Lighting designed by Kluckhuhn, Cabb and McDavid, Washington, D.C. Electrical contractor: Walter Truland Company, Arlington, Va.

There are 391 fixtures, using 1,564 square feet of LUCITE, illuminating about 30% of the total floor space in the building. The LUCITE is installed in a single frame of steel hinged to the fixture. The Housing Center has an average of 45 foot-candles, as opposed to the 30 foot-candles usually found in office buildings.

Better looking, better lighting

with fixtures of Du Pont LUCITE®

The National Housing Center, in the heart of the nation's capital, is the show place of the home-building industry and the headquarters of the National Association of Home Builders. The eight-story, $2,500,000 building serves as a storehouse of accumulated knowledge on home building and related matters and a focal point for all major housing activities. Contributing to the beauty and efficiency of this modern architectural center are lighting fixtures made of LUCITE acrylic resin.

Fixtures of LUCITE are used on three floors, containing the offices, library, conference rooms and work areas. Because they are made of Du Pont LUCITE, these fixtures transmit optimum light without specular glare or shadow. They are strong, durable, free from discoloration and dimensionally stable. Installation is a simple matter.

SEND FOR FREE BOOKLET. This 12-page illustrated booklet describes property and application data on LUCITE acrylic resin for lighting. For your free copy, write to E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Department, Room 434, Du Pont Building, Wilmington 98, Delaware.

DU PONT

REG. U.S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

Perfeclite now offers a new **hammer lock** design in incandescent ceiling pan lighting fixtures. No other ceiling pan fixture on the market today has all these engineering features:

- Globe opens on **hinge** for quick easy cleaning and relamping.
- Unique **safety locking fitter** holds globe in place without bothersome screws, unsightly extensions or trick springs. Globe is secured with lugs by simple twist of the wrist.
- Lip of globe is completely protected against breakage by a **steel protector ring.**
- Provides **ceiling illumination** as well as **evenly distributed floor lighting.**
- Minimum amount of metal, maximum amount of glass results in **highest light efficiency.**

Here is a unique ceiling pan fixture design for either commercial or residential installation. For further information send for The Perfeclite Data Sheet 56-C today.

Perfeclite's new **hammer lock** fixture is available in the following sizes:

Model	Glass Diameter	Wattage
HH-9	8″	2- 40 W
HH-11	10″	2- 60 W
HH-13	12″	2- 75 W
HH-15	14″	2-100 W
HH-17	16″	3-100 W

Send for new Perfeclite Catalog 956 giving full information on our entire line of Commercial Incandescent Fixtures and Exit Units.

Fixtures are Underwriters Laboratories, Inc. approved.

*Patent pending

THE PERFECLITE COMPANY

1457 East 40th Street • Cleveland 3, Ohio

☐ Please send me The Perfeclite Data Sheet 56-C.

☐ Please send me the new Perfeclite Catalog 956.

Name.....

Address.....

City..... .....State.....

PERFECLITE PRODUCTS — THE MARK OF LIGHTING SERVICE

NOW this store averages 50 foot-candles without glare or shadows . . . not even in the corners. Notice that ceiling does not go wall-to-wall, eliminating fitting around perimeter obstacles. The "Magic Ceiling" is fabricated by **The Wakefield Company,** Vermillion, Ohio.

BEFORE completion photo indicates the ease of installation. Strip lighting is already installed in foreground, while the ceiling in background is completed. All components are supplied in marked cartons, ready for use by electrical contractor.

Illuminated ceiling...

Throws new light on selling

Take a look in any corner of this sales area . . . not a "dead" spot to be found . . . every inch is selling! And, every client will welcome the neatness overhead. Pipes and ducts are hidden. Sprinklers can be concealed above this UL listed installation.

How is it done? Fluorescent strip lighting behind ceiling panels made of BAKELITE Brand Rigid Vinyl Sheet. These panels are easily removed for maintenance. They resist warping, cracking and discoloration . . . are normally unaffected by moisture, oil . . . clean easily, and are light-weight for easy handling. Complete data is available . . . write Dept. XA-82.

BAKELITE BRAND PLASTICS

BAKELITE COMPANY, *A Division of Union Carbide and Carbon Corporation* UCC 30 East 42nd Street, New York 17, N. Y.

The term BAKELITE and the Trefoil Symbol are registered trade-marks of UCC.

NEW General Electric bulletin tells . . .

HOW YOU CAN SOLVE YOUR BALLAST HEATING PROBLEMS

Send for your free copy today

You as a lighting engineer, architect, contractor, fluorescent lamp user or fixture manufacturer and we as ballast manufacturers are concerned with the basic problem of ballast heating.

Overheating drastically reduces lighting efficiency, ballast life, and results in wasted lighting dollars for everyone. G-E ballast engineers have long recognized this problem and are working constantly to design ballasts that give more uniform heat dissipation and longer operating life.

Intensive research by General Electric engineers shows that the solution involves much more than a carefully designed ballast. Surveys of heating problems indicate many other trouble spots.

Some of these are: Improper ballast application . . . misuse of building insulation . . . poor lamp maintenance . . . improper fixture design.

The trend to higher fluorescent lighting levels and higher-output lamp sources in industrial and commercial applications is increasing daily. This means that it is more important to you than ever before to be provided with more dependable and economical ballast operation.

In this new illustrated bulletin, "Lets Talk About Ballast Heating," General Electric engineers have laid the facts on the table. They carefully describe, in simple, easy-to-read language, the causes of ballast overheating, the basic heat problem, and what happens to an overheated ballast. But, most important, they tell what **you** can do to help prevent overheating. To get your free copy just fill out the coupon and send it in. Your copy will be sent to you by return mail.

If you have a specific heating problem right now, why not contact your nearest General Electric ballast sales engineer? He'll be glad to answer your questions and tell you how General Electric longer-life ballasts can help you save lighting dollars.

General Electric Co., Section D401-37
Schenectady 5, New York

Gentlemen: Please send me a FREE copy of your bulletin, "Let's Talk About Ballast Heating," GED-3328.

NAME.....

COMPANY.....

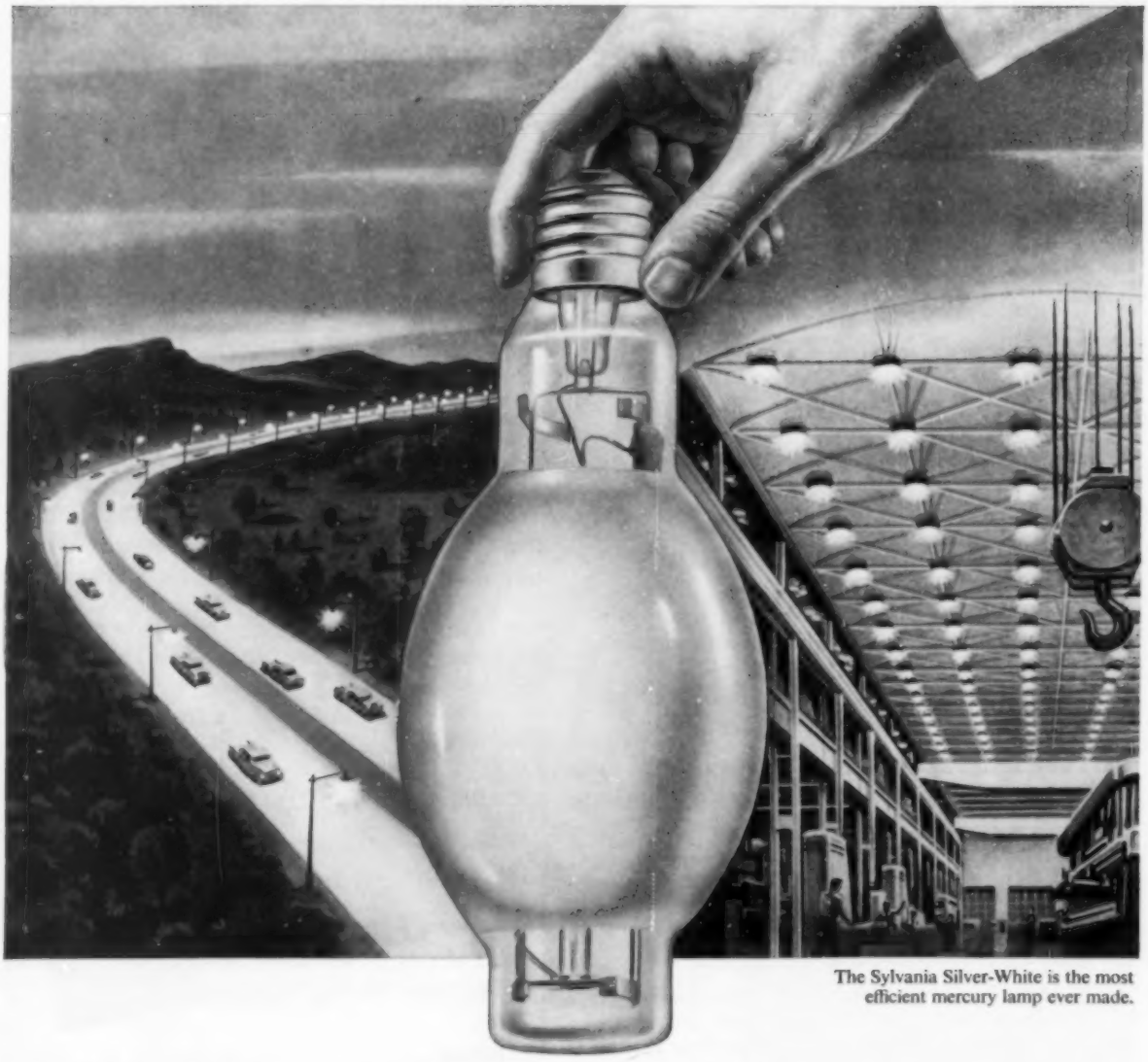
POSITION.....

STREET.....

CITY.....STATE.....

Progress Is Our Most Important Product

GENERAL ELECTRIC



The Sylvania Silver-White is the most efficient mercury lamp ever made.

For highway . . . or high-bay

. . . the one-lamp answer to both lighting needs

Today's most efficient mercury-vapor lamp is the new Sylvania Silver-White.

The greater light output and superior color quality of the Silver-White makes it an effective, versatile lighting source . . . it serves the high requirements for such widely different applications as highway lighting and high-bay plant illumination with unequalled efficiency.

Sylvania's Silver-White actually delivers up to 33% more lumens of light than previous color-improved mercury-vapor lamps. The 100-watt lamps, for example, are producing an unprecedented 4000 lumens in actual installations.

Sylvania Silver-White lamps cost no more than conventional color-improved lamps—but offer the combined economies of superior light output and superior construction.

Silver-White lamps are available in 100-, 175-, 400-, 700-, and 1000-watt types to meet the needs of industry for efficient high-bay indoor lighting and outdoor illumination for parking and loading areas . . . and for the governmental requirements for effective highway lighting.

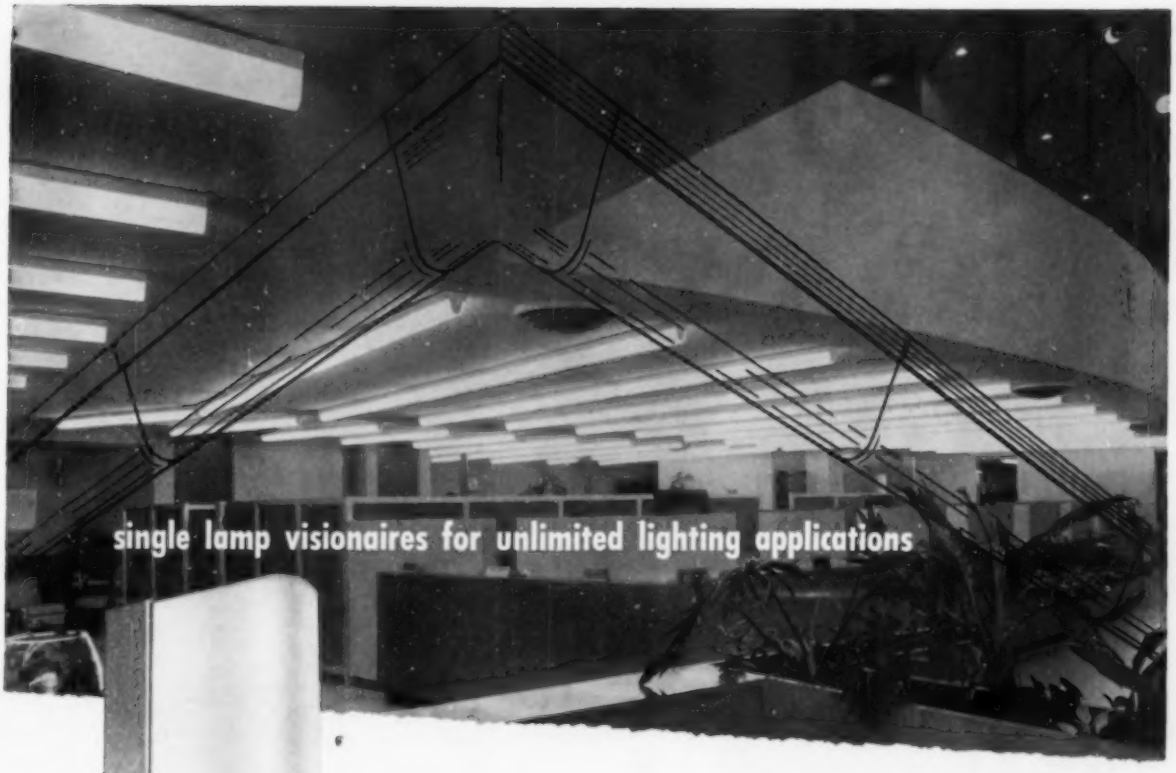
For complete information about the Sylvania Silver-White Mercury Vapor lamp, call your local representative, or write:

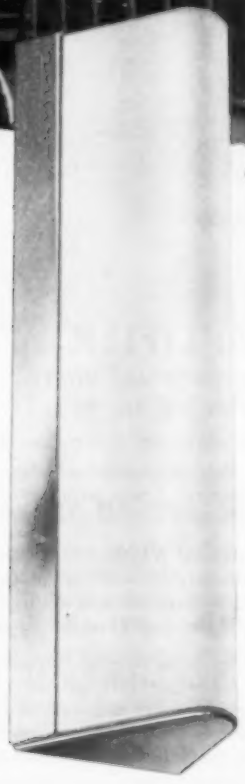
SYLVANIA ELECTRIC PRODUCTS INC.
Lighting Division, Dept. 7L-3504
60 Boston St., Salem, Mass.
In Canada: Sylvania Electric (Canada) Ltd.
Shell Tower Building, Montreal

SYLVANIA

. . . the fastest growing name in sight

LIGHTING • RADIO • ELECTRONICS • TELEVISION • ATOMIC ENERGY



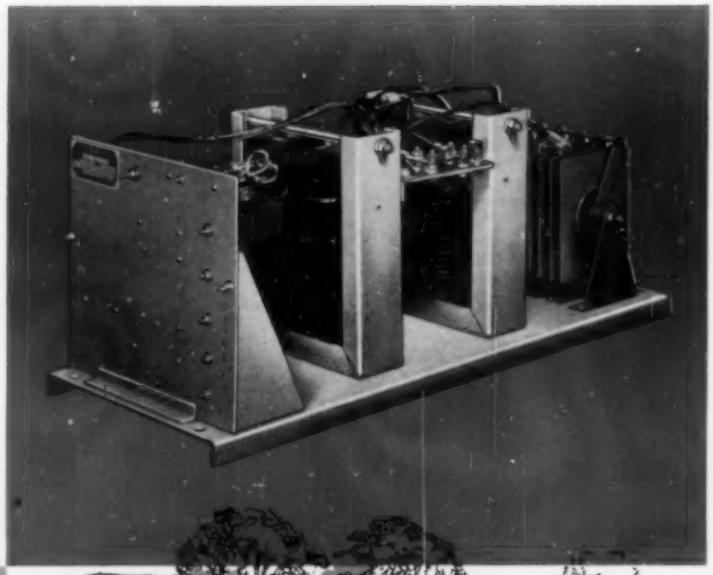


Here is versatile, shielded, single-lamp lighting for more applications than there's space to name with the Sunbeam P2801 Visionaire for corridors, library stacks, small parts bins, stairways, dressing rooms, over murals, paintings and commercial display areas or, as pictured, to form the general lighting system for smart contemporary interiors. Arrange patterns with the matching corner connector for uninterrupted geometric designs; follow contours or mount vertically on walls to provide local illumination. White plastic diffuser presents uniform surface brightness in all directions, snaps in or out with gentle "squeezing" motion. Low, low maintenance and tailored illumination distinction is assured whatever the application. Available in all standard lamp lengths.

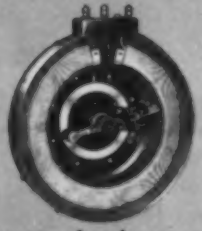
SUNBEAM LIGHTING COMPANY

777 East 14th Place, Los Angeles 21, California

Modern Lighting Control *for the modern theatre....*



Vickers Announces New *Varilux* Autotransformer Dimmers



Featuring

- 300 steps of voltage control
- designed for lighting control service
- linear output voltage
- ease of operation
- low power loss
- extremely long life

Vickers will be happy to help you with your lighting control problems—from a single autotransformer unit to the most complete system.

*TRADEMARK

VICKERS MAGNETIC AMPLIFIER TYPE DIMMERS!

Maximum flexibility...rapid between-scene changes... accurate control of lighting intensities. These are important requisites of lighting control switchboards for the modern stage.

In Purdue University's magnificent new $9,000,000 Memorial Union—Hall of Music Annex (above), 80 Vickers Magnetic Amplifier Type Dimmers have been incorporated in the lighting systems for the Loeb Playhouse and the Experimental Theatre.

These dependable dimmers meet today's exacting lighting control needs with: fast response, smooth transition through the entire lighting range, new 30-1 load range, inherent stability, reduced weight and size through redesigned closed-core power section, elimination of tubes and moving parts, and other superior features.

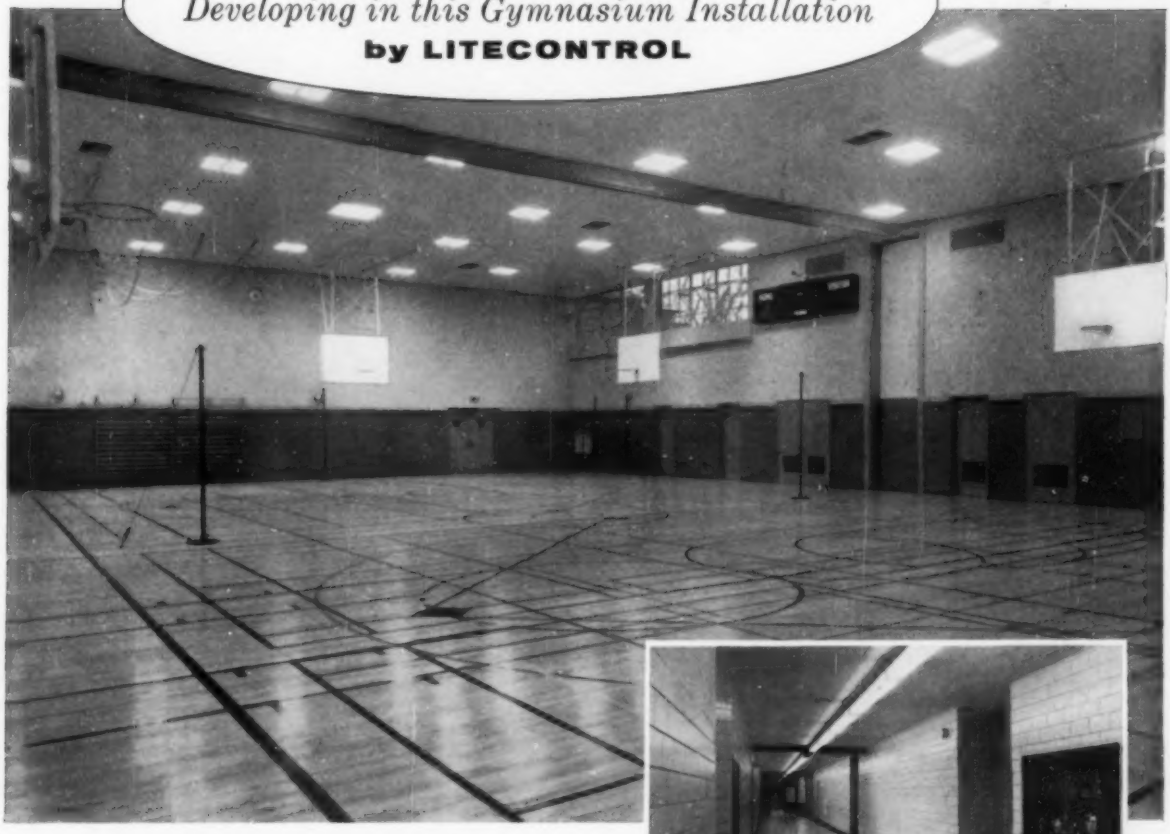
Write today for Bulletin 5000 on Magnetic Amplifier Dimmers as lighting control components.

VICKERS ELECTRIC DIVISION

VICKERS INCORPORATED a unit of Sperry Rand Corporation

1863 LOCUST STREET • SAINT LOUIS 3, MISSOURI

You can See Young Muscles
Developing in this Gymnasium Installation
by LITECONTROL



LITECONTROL Series 700 corridor fixtures were used in all corridors. (Also recommended for book stacks of libraries.) Although lamps are shielded by steel baffles, the fixture appears at a distance to have a luminous enclosure. Note the evenness of illumination here as well as in the gymnasium.

This installation conforms in all respects to the foot-candle standards shown in the "Manual of Certified Lighting" as set up by the National Lighting Bureau

Note the acoustical tile ceiling which permitted use of LITECONTROL recessed gym type lens boxes with four lenses in two hinged doors. The youngsters who play and work out in this gym will benefit by light superbly controlled by Holophane Hi-Stress (shock-resistant) lenses. Doors are easily opened and closed through spring catches.

Litecontrol makes this type fixture for recessed or surface mounting, with one, two, or four lenses. Later models have a ring in each spring catch to permit door opening and closing from the floor by means of a long pole. Thus relamping can be done easily without climbing 16 to 18 feet on a ladder. (See illustration.)

Like all Litecontrol equipment, the fixtures are built to last, of heavy gauge steel and welded. Whether the better *standard* lighting you are looking for is to help build muscles as in a gym, or to help build business as in a store — look to Litecontrol!

INSTALLATION: M. E. Fitzgerald School, Cambridge, Mass.
AREA: Gymnasium and corridors
ARCHITECT: M. A. Dyer Company, Boston, Mass.
ENGINEER: J. M. McCusker Associates, Boston, Mass.
LIGHTING SPECIALIST: R. J. Kearns, J. M. McCusker Associates
ELECTRICAL CONTRACTOR: Aetna Electric Company, Boston, Mass.
CEILING HEIGHT: Gymnasium, 20'-0"; corridors, 8'-6"
FIXTURES: Gymnasium, No. 12FV-GF-4SQ recessed, with Hi-Stress lenses, 4-300 watt lamps; Corridors, No. 718SL surface mounted, using F96T12 slimline lamps
INTENSITY: Gymnasium, average 47 foot-candles in service; Corridors, average 30 foot-candles in service

LITECONTROL
Fixtures
KEEP UPKEEP DOWN
LITECONTROL CORPORATION
36 Pleasant Street, Watertown 72, Massachusetts

DESIGNERS, ENGINEERS AND MANUFACTURERS OF FLUORESCENT LIGHTING EQUIPMENT DISTRIBUTED ONLY THROUGH ACCREDITED WHOLESALERS

New York City's "14th Street Association" proves modern whiteway lighting pays big dividends

With the use of P & K aluminum standards and LUXaire® Fluorescent Luminaires, the average light level on 14th Street, a major downtown shopping center, has been increased from 0.4 to better than 2 foot candles. The P & K LUXaire® units, specially designed in wedge shape, are mounted at 30-foot height on staggered 70-foot spacings.

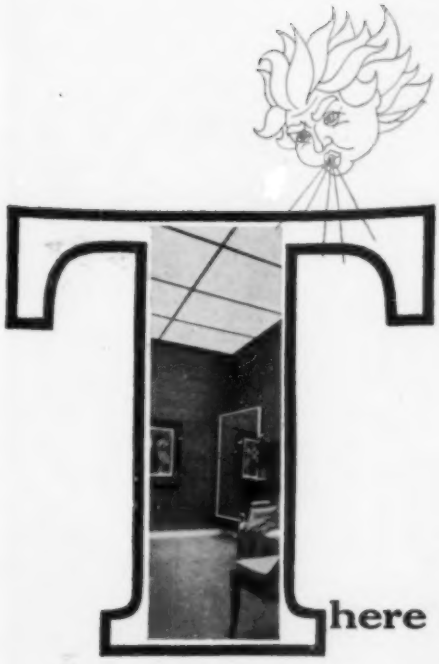
The choice of P & K equipment, combining high strength with light weight, permitted the use of existing electrical vaults with a minimum of excavation and foundation work. Installation was quick, easy, and low in cost. Negligible maintenance requirements, a feature of all P & K products, will serve to keep the *real* cost of lighting equipment on 14th Street surprisingly low.

Comments from the 14TH STREET ASSOCIATION, who paid for the new lighting: "New White way has accomplished its purpose . . . business improvement . . enhanced shopping area . . safer for shoppers and vehicular traffic. . . ."

WRITE FOR A COPY OF THE P & K LUXaire® Catalog . . . and use the P & K planning and advisory services without obligation.

P&K PFAFF & KENDALL

84 FOUNDRY ST., NEWARK 5, N. J.



There is only one light diffusing ceiling that actually helps circulate the air from overhead air conditioning and heating systems **(it's used solely for this purpose by air cooler manufacturers)** yet obscures overhead utility systems **(by 45 or 60 degree shielding)** while transmitting light with the greatest known efficiency and with the absolute minimum of surface glare....

HONEYLITE®

LIGHT-DIFFUSING ALUMINUM HONEYCOMB

A DEVELOPMENT OF HEXCEL PRODUCTS INC.

951-61ST STREET, OAKLAND 8, CALIFORNIA

Constitution Hall, Washington, D. C.

(DAUGHTERS OF THE AMERICAN REVOLUTION)

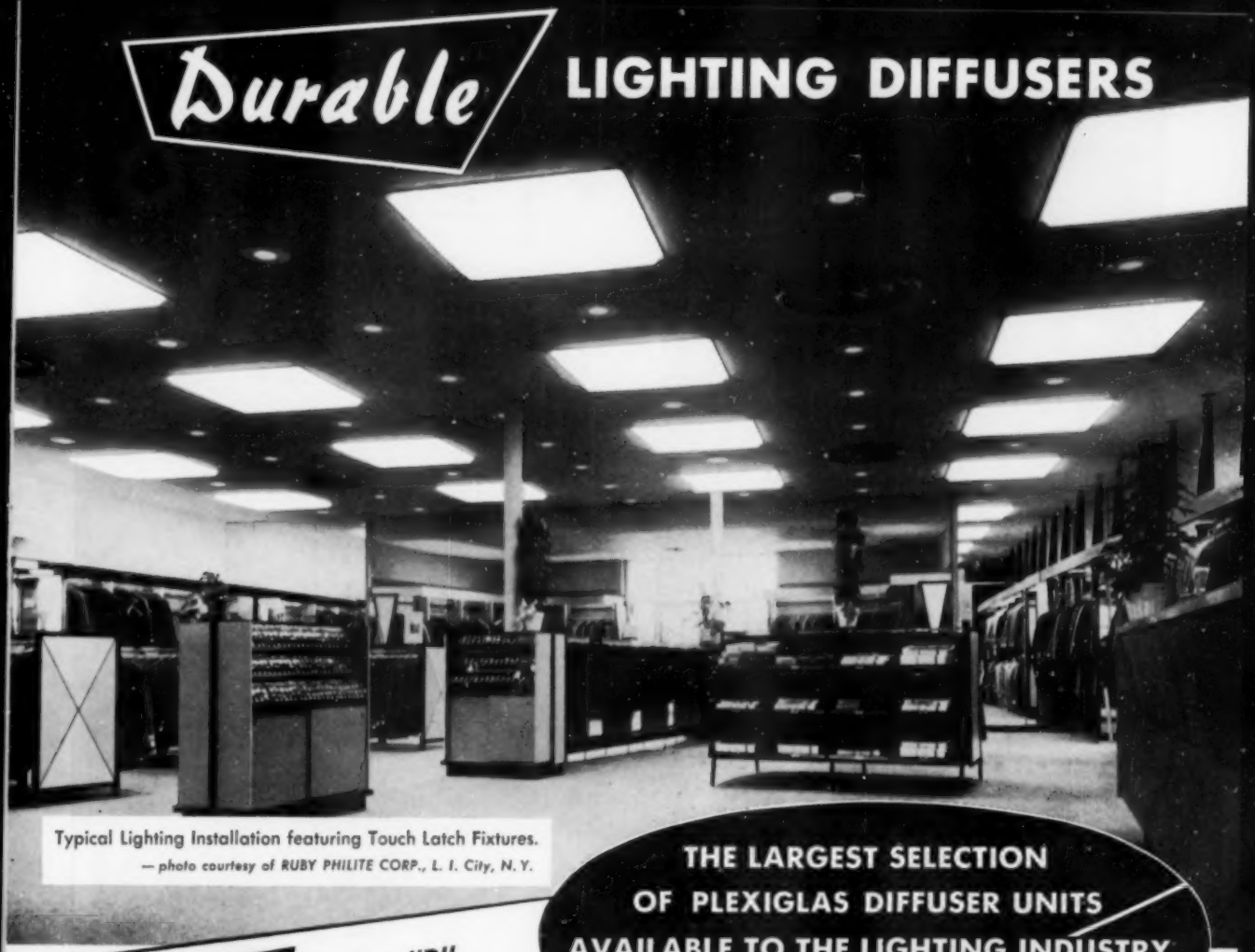
•

RELIGHTED BY RAMBUSCH UNDER THE SUPERVISION OF
BERNARD LYON FRISHMAN & ASSOCIATES, *Architects* • L. WARREN BOGAN & ASSOCIATES, *Consulting Engineers*

When it comes to lighting large and lofty interiors the Rambusch Downlite has no equal. It is efficient, safe, economical, simple to maintain, glare shielded and guaranteed to produce the promised results. • There are 100 Rambusch lighting representatives in the country—one of them is near you and anxious to serve you.

RAMBUSCH DESIGNERS • MANUFACTURERS
40 WEST 13th STREET, NEW YORK 11, N. Y.

Durable LIGHTING DIFFUSERS



Typical Lighting Installation featuring Touch Latch Fixtures.
— photo courtesy of RUBY PHILITE CORP., L. I. City, N. Y.

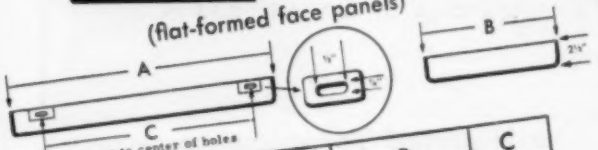
THE LARGEST SELECTION OF PLEXIGLAS DIFFUSER UNITS AVAILABLE TO THE LIGHTING INDUSTRY

22 MODELS

Durable Series "R"

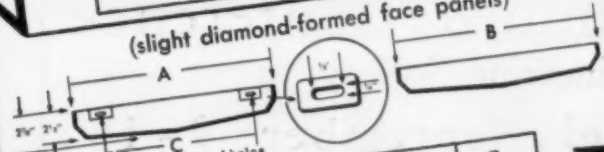
8 Standard Models

(flat-formed face panels)



Model No.	A	B	C
R-1248	47-31/32"	11-5/8"	24"
R-1236	35-31/32"	11-3/4"	18"
R-1224	23-31/32"	11-3/4"	12"
R-1548	47-15/16"	14-13/16"	24"
R-2424	23-31/32"	23-7/16"	12"
R-2448	47-15/16"	23-11/16"	24"
R-3636	35-15/16"	35-3/4"	24"

(slight diamond-formed face panels)



Model No.	A	B	C
R-4848	47-13/16"	47-13/16"	24"

In addition to the **Series "R"**
8 Standard Models (illustrated and specified)

our line includes **Series "U"**
6 Standard Models (flat-formed face panels)

Series "M"
2 Standard Models (ribbed panels)

DIFFUSER DOMES 4 Standard Models

CORRUGATED PANELS 2 Standard Models

ask for detailed literature, specification sheets and prices.

PLEXIGLAS is the registered trademark for acrylic plastic manufactured by Rohm & Haas Co., Philadelphia, Pa.

Durable FORMED PRODUCTS, INC.
6 Greene Street, New York 13, N. Y.
Phone: DIgby 9-2443-4

"THE FOREMOST NOTED FABRICATOR OF THERMOPLASTIC SHEETING"

Early street lighting unit at Whitehall and Alabama Streets, Atlanta, still burning as a memorial to the Old Guard Battalion of the Confederacy. In the background, a 20,000-lumen mercury vapor luminaire, typical of the street lights that make Atlanta one of the best lighted cities in the U.S.

ATLANTA

HAS A
CANDLE IN
THE WINDOW
For

I·E·S

THIS YEAR

IN ADDITION TO . . .

a full presentation of the latest developments in the art and science of illumination.

WE ARE PLANNING . . .

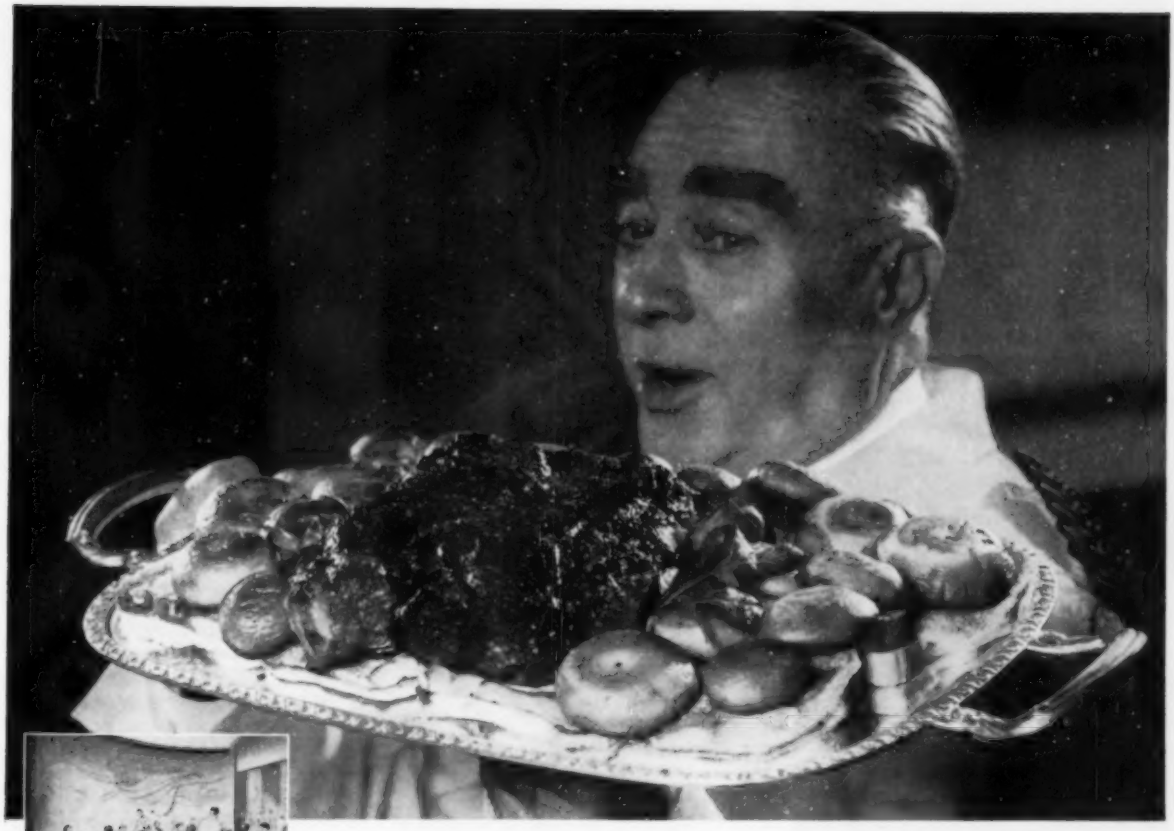
- **A Plantation Party**
- **An Old Fashioned Barbecue**
- **Historical Tours**
- **Ladies' Events**
- **Golf**

Y'all Come!

1957 National Technical Conference

Illuminating Engineering Society

Atlanta Biltmore Hotel September 9 - 13



Put Extra SIZZLE in the Steaks

— with LUXTROL Light Control Equipment

The right level of light even makes food taste better. It teams up with smart decor and suave waiters to help keep customers coming back.

But the right light level changes with the time of day! LUXTROL light control equipment can make that change smoothly and without flickering.

Light control brings a new fourth dimension to interior design — the dimension of time. It lets the appearance of your decor change from hour to hour by changing the light level — to match a mood . . . or set a mood . . . have customers linger and spend more . . . or hurry and make way for others.

LUXTROL light control equipment can be used on incandescent, fluorescent and cold cathode lamps. In the complete line you will find units to meet all requirements from 360 to 30,000 watt loads.

Send coupon below for more information.

LUXTROL

Light Control Equipment

Non-Interlocking Types When only a few circuits require control. Capacities from 1000 to 30,000 watts.

Package Types 6000 to 15,000 watt ratings. Circuits can be interlocked. Professional light control at budget prices.

Interlocking Types Single units in 2500 and 6000 watt ratings for mounting in switchboard assemblies.

Type WSD 360 A compact unit designed to replace the ordinary "on-off" switch in a wall. 360 watt rating.

Magnetic Amplifier Systems No moving parts or electronic tubes. Available in 3000, 6000 and 15,000 watt ratings.

a precision product of

THE SUPERIOR ELECTRIC COMPANY

704 ROGER ROAD, BRISTOL, CONNECTICUT

Name_____

Company_____

Street_____

City_____ Zone____ State_____

Selective coverage by means of an accurately shaped beam of light is possible only with an optical system using a focusing lens and a masking diaphragm or shutter. Century makes the widest variety of these instruments in a full range of sizes and mounts.

CENTURY
LIGHTING, INC.
521 WEST 43rd ST.
NEW YORK 36, N. Y.
1820-40 BERKELEY ST.
SANTA MONICA, CALIF.
1477 N.E. 129th ST.
N. MIAMI, FLORIDA

(*Continued from page 16A*)

Dynaseal Lighting Corp. announces the election of **John J. Caldwell** as Vice-President and General Sales Manager. Under Mr. Caldwell's direction will fall the development of a distributor sales organization throughout the country.

Westinghouse Electric Corp. has opened a Pacific Coast distribution center at Ogden, Utah, first in a nationwide network of centers planned by the company. **Joseph C. Belloni** has been named as Pacific Coast manager of distribution and resident director of the new center. Mr. Belloni, who joined Westinghouse 26 years ago, has been Pacific Coast order service manager.

Robert Stuart Smith has joined the National Lighting Bureau in the capacity of field representative. Mr. Smith formerly administered public relations projects for the American Museum of Immigration and for the New Orleans Port Commission. He will operate from the Bureau's office in the National Electrical Manufacturers Association headquarters in New York City.

Kuhlman Electric Co., Bay City, Mich., has appointed **Justin A. Zager** as Northern regional sales manager for the transformer division. Mr. Zager's offices will be located at 172 McKinley Parkway, Buffalo, N. Y.

Reorganization of the General Electric Lamp Division's Warehousing and Field Service Section has been announced. **Roy L. Johnson,** manager of the Finance, has been appointed acting manager of Warehousing and Field Service, and will be stationed at Nela Park. Six new service regions have been set up, with managers who will report to Mr. Johnson. Twenty-six service district managers will report to the new regional managers. The new regions and managers are: Western Service Region, with headquarters in Oakland, Calif, with **Robert G. Weiland** as manager; Central Service Region, with headquarters in Chicago, **George A. LeRuez** as manager; Midwestern Service Region, with headquarters in St. Louis, **Harlan E. Lindbert,** manager; East Central Service Region, with headquarters in Cleveland and **Harry P. Thatcher,** manager; Eastern Service Region, with headquarters in New York City, with **John A. Amport** as manager; Southern Service Region, headquartered in Atlanta, with **Alex C. Ham** as manager. Mr. Weiland has been replaced in the New York District by **John J. Gates;** Mr. LeRuez in the Chicago District by **William P. Duff;** Mr. Lindbert in the Dallas District by **Darrel D. Lingle;** Mr. Amport as manager in Newark, N. J. by **Nelson E. Varnum.** In addition, a Warehousing and Transportation Sub-Section has been established, with **James B. DeArment,** manager. Mr. DeArment is located at Nela Park.

BOOKS AND PAMPHLETS

Bright Ideas for Brighter Living, available from Sylvania Electric Products Inc., 1100 Main St., Buffalo 9, N. Y.

Featuring a theme of decorating with light, this 16-page two-color booklet shows, in pictures and sketches, uses of light and color for decorative effects as well as special lighting ideas. Sections are included on both exterior and interior areas.

NEMA Standards, available from the National Electrical Manufacturers Association, 155 East 44th St., New York 17, N. Y., at prices per copy as marked for each.

EEI-NEMA Standards for Street and Highway Lighting:

SH 7-1956, Steel Luminaire Supports for Wood Poles, 15 cents.

SH 8-1956, Film Cutouts, 25 cents.

SH 10-1956, Metal Head and Reflector Interchangeability, 25 cents.

SH 11-1956, Insulator Head and Reflector Interchangeability, 25 cents.

NEMA Standards Publication for Enclosed Switches, KS 1-1956, $1.

NEMA Standards Publications for Panelboards, PB 1-1957, $1.

Incandescent Lighting Guide Book, available from Sylvania Electric Products Inc., 1100 Main St., Buffalo 9, N. Y.

More than 1800 types and sizes of incandescent lamps are discussed in this 24-page booklet, which features sections on the characteristics of incandescent lamps, structure, filaments, bulb sizes, glass types and finishes, types of lamp bases, and performance characteristics.

Farm Electrification Research, published by Edison Electric Institute, 420 Lexington Ave., New York 17, N. Y. 60 pages. $1.25 per copy.

The third edition of this report, this booklet was compiled by the Institute's Farm Group and summarizes 222 separate research projects or special studies receiving support from electric companies, from 29 states and Canada. The studies fall in 87 different categories.

The report is said to contain information on activities not covered in similar reports published in 1949 and 1950.

IT SEEMS TO ME

I.E.S. Reaches Rimouski

Since Fred Guth took over the Sustaining Membership Committee, Council has become accustomed to considering a long list of new applications for membership at each meeting. Most of these applications come from utilities and distributors in large urban centers, and it is only when one of them comes from a remote area that curiosity is aroused. Such an application was received at the February Council meeting, from La Compagnie Mitis Limitee of Rimouski, Quebec.

Rimouski is a charming French Canadian town on the shores of the St. Lawrence River 300 miles northeast of Quebec City. Close by is Pointe-au-Pere, from which the little boats go out to meet the transatlantic liners with a pilot to guide them up the St. Lawrence River to Montreal and the Great Lakes ports. Here also starts the famous scenic highway around the Gaspe coast, now doubly important because of recent discoveries of copper and other important minerals. Fishing and lumber used to be the way of life, but progress is wresting the secrets from the big black mountains and whole new towns are appearing in a former wilderness.

This is the territory in which J. Henri Labrie operates a very successful wholesale business in "accessoires electriques." He is a progressive merchandiser and is also a director of the Lower St. Lawrence Power Co. Even in this territory the reputation of I.E.S. is well known. The Quebec Chapter has been holding meetings in French for many years and the brand new towns and the mines and other industrial establishments will be better places to live and work in due to the influence of I.E.S. Recommended Practices. We welcome you to our Society, M. Labrie.—JOSEPH THOMAS, *Canadian Regional Vice-President.*

NEW MEMBERS

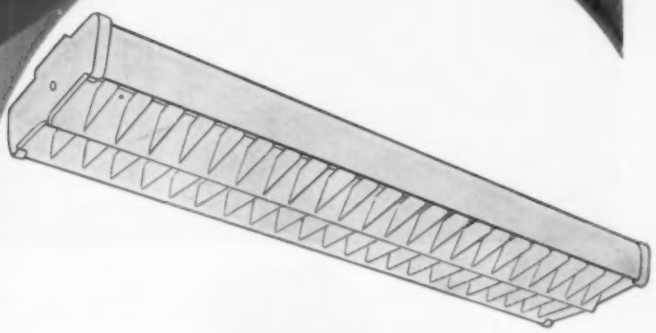
At the meeting of the I.E.S. Council Executive Committee held at New York, N. Y. on March 14, 1957, the following were elected to membership. Names marked * are transfers from Associate Member Grade.

ARIZONA SECTION

Hinckley, W. E., New State Electric Co., Phoenix, Ariz.

(*Continued on page 52A*)

L&P Fluorescent Fixtures



THE WESTERNER

A high style, quality fixture of real beauty. Adds distinction and style to any office, elegant in any type of general installation. It's a beauty!

In the Spotlight FOR APRIL

This L & P fixture is only one of Light & Power's complete line of fluorescent fixtures—with fine material, expert craftsmanship and quality control built into every unit. The result? Dependability, beauty and efficiency . . . every time!

LIGHT & POWER UTILITIES CORP.

Distributed by Electrical Wholesalers Only

Write or wire today for catalog and prices.

LIGHT & POWER UTILITIES CORP.
1035 Firestone Blvd., Memphis, Tenn.

design by mcPhilben

for The New House of Seagram

Superbly contemporary in design

Architects:
Mies van de Rohe
& Philip Johnson
Associate Architects:
Kahn & Jacobs
Electrical Engineers:
Clifton E. Smith
Lighting Consultant:
Richard C. Kelly
Electrical Contractors:
Fischbach & Moore, Inc.

Selected to light the stairways of the new House of Seagram in New York, the McPhilben 43-40 wall bracket offers these exclusive advantages: solid cast aluminum construction... gleaming satin finish... dust-free and bug-tight operation... a larger, threaded tapered globe which gives greater diffusion, lower operating temperatures and longer lamp life.

Wall and ceiling units are made in 100 and 200 watt sizes. Both are available in a UL approved vapor-tight series and may be fitted with cast aluminum protective guards.

See the McPhilben sales representative in your area or write for full 43-40 specifications to: McPhilben Lighting Co., 1331 Willoughby Ave., Brooklyn 37, N. Y.

Representatives in major cities • Stocked by electrical wholesalers

(*Continued from page 51A*)

ARK-LA-TEX CHAPTER

Associate Member:

Pons, Carl, Carl Pons Electric Co., Shreveport, La.

BRITISH COLUMBIA SECTION

Associate Members:

Fraser, A. J., Gough & Co., Vancouver, B. C.
Jones, Miss Laureen M., B. C. Electric Co., Vancouver, B. C.
McIntosh, A. J., Sylvania Electric (Canada) Ltd., Montreal, Que.

CAPITAL SECTION

Associate Member:

Cockrill, C. R., 1710 Abingdon Dr., Alexandria, Va.

CENTRAL ILLINOIS CHAPTER

Member:

*Walker, W. F., Public Service Co., Dixon, Ill.

Associate Members:

Bush, E. C., Ace Electric, Pekin, Ill.
Crowl, Edna A., Crowl Electric Co., Peoria, Ill.

CENTRAL NEW YORK SECTION

Associate Members:

Best, R. C., Sargent, Webster, Crenshaw & Folley, Syracuse, N. Y.
Fleischman, F. F., Jr., Corning Glass Works, Corning, N. Y.

CHICAGO SECTION

Associate Members:

Barkley, T. J., General Electric Co., Chicago, Ill.
Stark, R. E., State of Illinois, Division of Highways, Chicago, Ill.
Thompson, J. R., General Electric Co., Chicago, Ill.

Student Members:

Haftel, Enrique, University of Illinois, Champaign, Ill.
McAfee, C. L., University of Illinois, Urbana, Ill.
Sullivan, D. D., University of Illinois, Urbana, Ill.
Wiggins, E. D., University of Illinois, Urbana, Ill.

CLEVELAND SECTION

Associate Members:

Brooks, R. J., Sun Lite Fluorescent Maintenance Co., E. Cleveland, Ohio.
Edwards, R. N., Jr., Westinghouse Electric Corp., Cleveland, Ohio.
Levine, Charles, Sun Lite Fluorescent Maintenance Co., E. Cleveland, Ohio.

CORNHUSKER SECTION

Member:

Glass, E. W., Nebraska Commonwealth Electric Co. Inc., Omaha, Nebr.

Associate Members:

Pace, D. P., Pace Electric Co. Inc., Omaha, Nebr.
Sandusky, Lowell, Wincharger Corp., Sioux City, Iowa.

EASTERN PENNSYLVANIA SECTION

Associate Members:

Diefenderfer, Orlando, 116 S. 2nd St., Allentown, Pa.
McColly, J. E., Swedish Iron & Steel Corp., Harrisburg, Pa.

EDMONTON CHAPTER

Member:

Raisbeck, G. R., Canadian Westinghouse Supply Co., Edmonton, Alta.

Associate Members:

Ford, L. H., Canadian General Electric Co., Edmonton, Alta.

Jeffels, D. D., A. D. Morton (Electrical) Ltd., Edmonton, Alta.
Scott, K. N., Dept. of Transport, Edmonton, Alta.

FOREIGN NON-SECTION

Member:
Belefant, Arthur, Ammann & Whitney—Consulting Engineers, P. O. Box 522, Athens, Greece.
Associate Member:
Benzio, Virgilio, OSRAM, Via Broggi, 4, Milano, Italy.

GEORGIA SECTION

Member:
Howe, C. F., 1722 Candler Bldg., Atlanta, Ga.
Associate Members:
Bartenfeld, T. A., Jr., Bartenfeld Electric Co., Atlanta, Ga.
Landers, P. D., Rohm & Haas Co., Atlanta, Ga.

GOLDEN GATE SECTION

Member:
Skootsky, Harold, State of California, Div. of Highways, San Francisco, Calif.
Associate Member:
Michaelis, C. F., Pacific Gas & Electric Co., Vallejo, Calif.

HEART OF AMERICA SECTION

Associate Members:
Alber, D. R., Alber Electric Co. Inc., Kansas City, Mo.
Bodner, A. E., Burns & McDonnell Engineering Co., Kansas City, Mo.
Rensenhouse, C. K., Rossner Electric Co., Kansas City, Mo.
Thompson, J. W., Graybar Electric Co., Kansas City, Mo.
Wolfe, D. F., Boeing Airplane Co., Wichita, Kans.

INLAND EMPIRE CHAPTER

Associate Member:
Schertel, S. E., Public Utility Dist. No. 1, Wenatchee, Wash.

MARYLAND SECTION

Associate Members:
Martin, J. A., Whitman, Requardt & Assoc., Baltimore, Md.
Parker, C. A., Whitman, Requardt & Assoc., Baltimore, Md.

MICHIGAN SECTION

Member:
Kochajda, V. L., Franc C. Teal Electric Co., Detroit, Mich.
*Pilch, Paul, Smith Bros. Electric, Inc., Detroit, Mich.
Associate Members:
Bogloff, Tony, H. E. Beyster & Assoc. Inc., Detroit, Mich.
Brauning, G. E., H. E. Beyster & Associates Inc., Detroit, Mich.
Gabler, L. A., Detroit Edison Co., Detroit, Mich.
Godin, A. J., Verd-A-Ray Corp., Detroit, Mich.
Heenan, G. A., Leo J. Heenan, Pontiac, Mich.
Heenan, L. J., 15 Carlton Court, Pontiac, Mich.
Peterson, Miss Pauline, 311 E. Woodland, Ferndale, Mich.
Ronan, H. J., Sylvania Electric Products, Detroit, Mich.
Shelly, Jerry, Royalite Electric Supply Co., Flint, Mich.
Smith, I. W., Commonwealth Associates Inc., Jackson, Mich.
Van Herweg, H. J., J. Georger Fischer & Sons Inc., Saginaw, Mich.
Waitz, Howard, Madison Electric Co., Detroit, Mich.

MID-SOUTH CHAPTER

Member:
Akes, E. A., 602 A. Main St., Savannah, Tenn.

(Continued on page 54A)

SHEFFIELD ANNOUNCES NEW EVER-WHITE SHIELDS WITH THREE TIMES LIGHT STABILITY, SAME PRICE AS REGULAR SHIELDS

Now you can improve the quality — and saleability — of your plastic-shielded fluorescent fixtures at no extra cost.

Sheffield's new EVER-WHITE polystyrene shields have more than three times the light stability, yet cost no more than regular polystyrene shields. Furthermore, these shields are interchangeable with existing stocks because color, hiding power, light transmission and all other properties are identical.

Because of their light stability and identical quality and cost, we are switching our entire production to EVER-WHITE. Hereafter, your orders for regular plastic shields will be filled with EVER-WHITE shields — at no extra cost to you.

Get the jump on competition by ordering Sheffield EVER-WHITE shields now. (If you have no die with us, one of our representatives will be glad to show you our complete line of stock dies, one of which may meet your requirements.)

For full details on EVER-WHITE shields, contact your nearest Sheffield representative or write to Sheffield Plastics, Inc., Dept. 72-B, Sheffield, Mass.

PHYSICAL PROPERTIES OF POLYSTYRENE

PROPERTY	REGULAR GRADE	EVER-WHITE GRADE
Specific Gravity	1.05	1.05
Tensile Strength, lbs./sq. in.	7000	7000
Modulus of Elasticity	4-5 x 10^5	4-5 x 10^5
Impact Strength, Izod, ft. lbs./in. of notch	0.25-0.35	0.25-0.35
Thermal Expansion, in./in./°C	6-8 x 10^{-5}	6-8 x 10^{-5}
Heat Distortion, °F @ 264 p.s.i.	183-191	183-191
Light Transmission, in white translucent color, percent	1-70	1-70
Color Possibilities	Unlimited	Unlimited
Burning Rate, inches/min.	I	I
Light Stability index, from actual exposure to light from fluorescent tube	1.0-1.5	>3.0*

* Sample still under test

Precision Engineered Rigid Plastics Extrusions

SHEFFIELD PLASTICS INC.
SHEFFIELD, MASS.

(Continued from page 53A)

Associate Member:

Harrington, D. J., Westinghouse Electric Corp., Memphis, Tenn.

Student Members:

Brooks, W. G., Southern College of Optometry, Memphis, Tenn.

Gardner, J. P., Jr., Southern College of Optometry, Memphis, Tenn.

MONTREAL SECTION

Members:

*Brooks, D., Shortall Electric Ltd., Montreal, Que.

*Gaudette, G. M., Sylvania Electric (Canada) Ltd., Drummondville, Que.

Associate Members:

Lefebvre, J. W., 680 Jean Talon, Montreal, Que.

Luggar, D. E., Northern Electric Co. Ltd., Montreal, Que.

Poliquin, P. A., Bedard-Girard Ltd., Montreal, Que.

MOTHER LODE CHAPTER

Associate Members:

Jennings, R. P., General Electric Supply Co., Sacramento, Calif.

Miller, R. E., General Electric Supply Co., Sacramento, Calif.

NEW ENGLAND SECTION

Associate Member:

Fougere, H. A., Central Maine Power Co., Portland, Maine.

NEW MEXICO CHAPTER

Associate Members:

Lopez, Gilbert, Carl R. Albach, Santa Fe, N. M.

Peddy, Olen, Public Service Co. of N. M., Albuquerque, N. M.

Student Members:

Badagard, Wayne A., Public Service Co. of New Mexico, Albuquerque, N. M.

Jarman, A. J., Public Service Co. of New Mexico, Albuquerque, N. M.

NEW ORLEANS SECTION

Associate Member:

Bagur, P. E., Jr., Pierre E. Bagur, Jr. & Co., New Orleans, La.

NEW YORK SECTION

Members:

Converso, Victor, Port of N. Y. Authority, New York, N. Y.

Jae, David, Jae & Meyer Co. Inc., Mt. Vernon, N. Y.

Laier, W. F., Neo Ray Products Inc., New York, N. Y.

Wechsler, Milton, Neo Ray Products Inc., New York, N. Y.

Young, Philip, Neo Ray Products Inc., New York, N. Y.

Associate Members:

Baldinger, Daniel, Louis Baldinger & Sons, Inc., Brooklyn, N. Y.

Broughel, E. R., General Electric Co., New York, N. Y.

Gellman, Martin, Neo Ray Products Inc., New York, N. Y.

Osach, N. J., J. J. Spath, Inc., New York, N. Y.

Sheldon, Seymour, Neo Ray Products Inc., New York, N. Y.

OIL CAPITAL SECTION

Associate Member:

Alfrey, J. H., Duro-Test Corp., North Bergen, N. J. (Alvin Hotel, Tulsa, Okla.)

OTTAWA CHAPTER

Associate Member:

Fee, J. K., Public Utilities Commission of Kingston, Kingston, Ont.

PALMETTO CHAPTER

Associate Members:

Donley, J. M., John S. Myers & Associates, Columbia, S. C.

Ward, R. L., Ward Electric Co., Greenville, S. C.

Williams, E. M., Cashion Co., Columbia, S. C.

PHILADELPHIA SECTION

Member:

Shermer, F. C., Philadelphia Electric Co., Philadelphia, Pa.

Associate Members:

Blum, Louis, Keystone Electric Co., Philadelphia, Pa.

Clayton, R. H., Bob Clayton Electric, Philadelphia, Pa.

Charette, G. F., Day & Zimmerman, Inc., Philadelphia, Pa.

Cook, A. M., General Electric Co., Philadelphia, Pa.

Cronan, G. L., Metalcraft Products Co., Philadelphia, Pa.

Donaghue, L. C., Electrical Association of Philadelphia, Pa.

Dudkin, N. T., 213 Rosewood Ave., Aldan, (Delaware Co.), Pa.

Geary, L. E., J. B. Derr Associates, Philadelphia, Pa.

Keough, R. H., Robert Keough & Co., Philadelphia, Pa.

Kirkpatrick, W. H., Jr., Sylvania Electric Products Inc., Philadelphia, Pa.

Mitchell, C. W., General Electric Co., Philadelphia, Pa.

Schaub, W. H., General Electric Co., Philadelphia, Pa.

Scholl, R. S., Sylvania Electric Products Inc., Philadelphia, Pa.

Sterner, A. E., Allen Lane & Scott, Philadelphia, Pa.

Stevenson, F. R., Atlantic Refining Co., Philadelphia, Pa.

Wenner, R. W., Revere Electric Mfg. Co., Philadelphia, Pa.

Williams, Perry, Perry Williams Co., Philadelphia, Pa.

PITTSBURGH SECTION

Member:

Danko, J. T., 909 Keystone Bldg., Pittsburgh, Pa.

ROCHESTER SECTION

Associate Member:

Johns, V. E., Jr., C. Storrs Barrows & Associates, Rochester, N. Y.

ROCKY MOUNTAIN SECTION

Member:

Patterson, G. H., General Electric Supply Co., Denver, Colo.

ST. LOUIS SECTION

Member:

*Buzan, Milton, Day-Brite Lighting Inc., St. Louis, Mo.

SAN JACINTO SECTION

Associate Members:

Burgess, G. W., Sylvania Electric Products Inc., Houston, Texas.

Garrett, W. A., III, Walker & Associates, Houston, Texas.

SOUTHEAST FLORIDA CHAPTER

Student Member:

Eicholtz, G. F., Jr., University of Miami, Miami, Fla.

SOUTHERN CALIFORNIA SECTION

Associate Members:

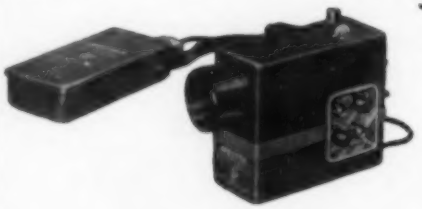
Cheatham, Francis, County of Orange Road Dept., Santa Ana, Calif.

Dugan, L. O., Jefferson Electric Co., Los Angeles, Calif.

Kramer, E. J., Maddox Sales Co., Los Angeles, Calif.

Massie, P. E., Day Ray Products Inc., S. Pasadena, Calif.

SPECTRA BRIGHTNESS SPOT METER



Spectra Meter Now Used by Lighting Engineers in . . .

Aircraft Industry
Electric Utilities
Architectural Firms
Motion Pictures & TV
Street & Highway Departments
Model Work
Human Engineering

Special Features of Standard Model:

Extreme Sensitivity Range
Direct Reading in ft-L
Locking Microammeter
Focusing 5′ to ∞
Small Angle

Other Models Available For Greater Sensitivity

DIRECT READING! All operators will obtain the same reading of the brightness of a given area.

Write for descriptive literature, complete specifications and information applying to your particular field to:

PHOTO RESEARCH CORP

837 N. CAHUENGA BLVD.
HOLLYWOOD 38, CALIF.

Thuro, G. M., Austin-Field & Fry, Los Angeles, Calif.

SOUTHWESTERN SECTION

Member:

Buchanan, G. C., The Union Metal Mfg. Co., Dallas, Texas.

Associate Members:

Deck, J. B., Sr., Texas Power & Light Co., Cleburne, Texas.
Welch, J. B., Smith Perry Electric Co., Dallas, Texas.

TAR HEEL SECTION

Member:

Rouse, D. E., Watson & Hart, Greensboro, N. C.

Associate Members:

Alexander, J. F., General Electric Supply Co., Greensboro, N. C.
Becker, J. F., General Electric Supply Co., Greensboro, N. C.
Calder, J. N., Jr., The Industrial Electric Co., Charlotte, N. C.
Lasley, R. M., General Electric Supply Co., Greensboro, N. C.
Oliver, E. T., L. W. Roberts, Greensboro, N. C.
Petersen, R. W., General Electric Co., Greensboro, N. C.

TORONTO SECTION

Member:

Kermath, C. T., Canadian General Electric Co., Toronto, Ont.

TWIN CITY SECTION

Member:

Wheeler, G. C., Northern States Power Co., Minneapolis, Minn.

Associate Members:

Finn, M. C., General Electric Co., Minneapolis, Minn.
Greenwood, Harmen, Northern States Power Co., Sioux Falls, S. D.
Lowe, H. H., City of St. Paul, St. Paul, Minn.
Strehlow, H. F., Edwin F. Guth Co., St. Paul, Minn.

TWIN PORTS CHAPTER

Associate Member:

Mahan, H. G., Benson Electric Co., Superior, Wis.

VANCOUVER ISLAND CHAPTER

Associate Members:

Button, A. A., Canadian Westinghouse Supply Co. Ltd., Victoria, B. C.
Mawson, Tom, Mawson Gage Ltd., Victoria, B. C.

VIRGINIA CHAPTET

Member:

Miller, J. S., Jr., University of Virginia, Charlottesville, Va.

WESTERN MICHIGAN SECTION

Associate Members:

Fuller, W. W., Verd-A-Ray Corp., Lansing, Mich.
Killman, E. H., The E. H. Killman Co., Cheboygan, Mich.
Wright, H. B., Sylvania Electric Products Inc., Lansing, Mich.

WESTERN NEW YORK SECTION

Associate Members:

Rooney, B. J., Board of Education, Buffalo, N. Y.
Woodley, R. J., Board of Education, Buffalo, N. Y.

WINNIPEG CHAPTER

Associate Members:

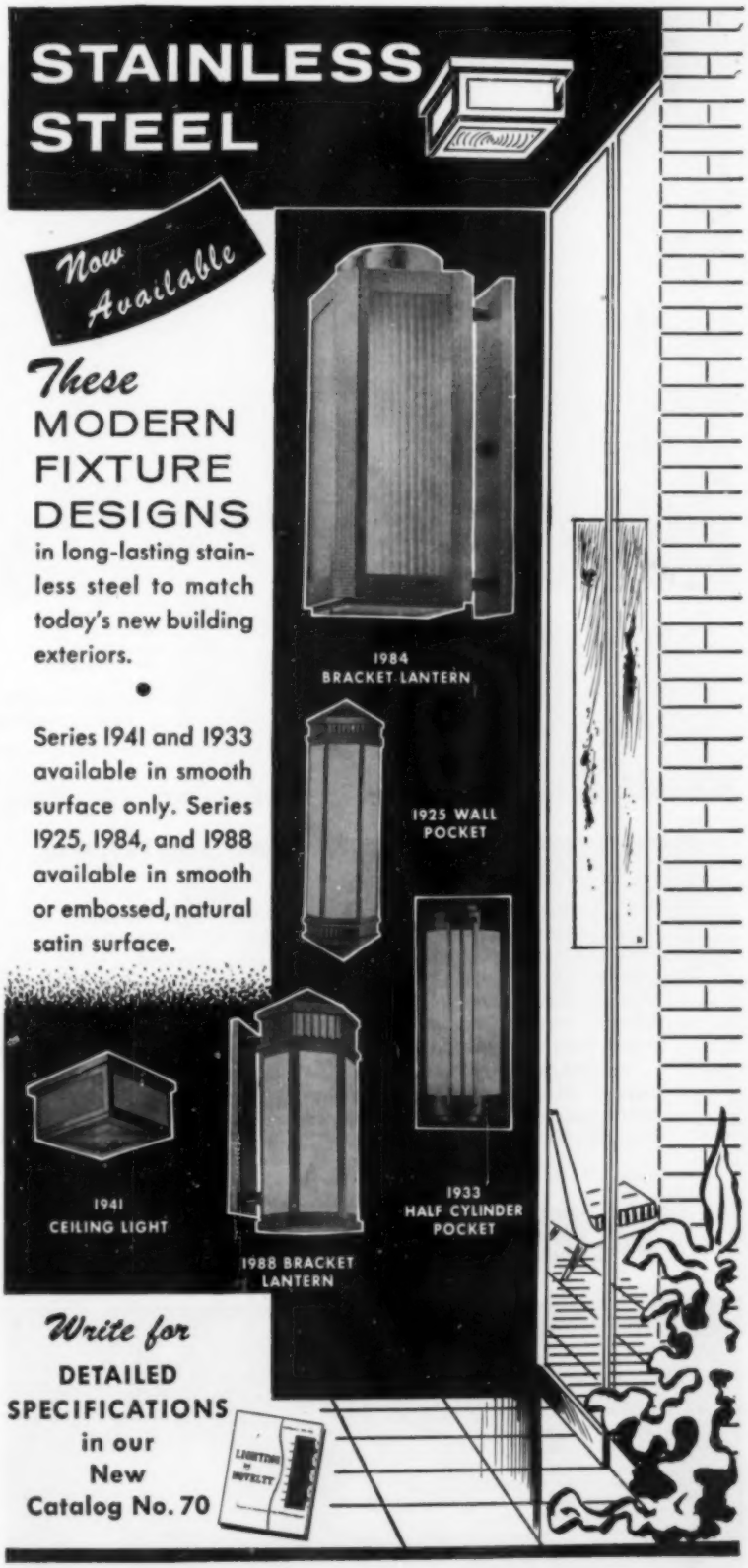
Dufort, D. D., Canadian General Electric Co. Ltd., St. James, Man.
Orton, C. H., Amalgamated Electric Corp., Ltd., Winnipeg, Man.

STAINLESS STEEL

Now Available

These MODERN FIXTURE DESIGNS in long-lasting stainless steel to match today's new building exteriors.

Series 1941 and 1933 available in smooth surface only. Series 1925, 1984, and 1988 available in smooth or embossed, natural satin surface.



Write for DETAILED SPECIFICATIONS in our New Catalog No. 70

The NOVELTY LIGHTING *Corporation*
2490 EAST 22nd STREET
CLEVELAND 15, OHIO

Keeping industry bright with ABolite

AMERICAN METAL PRODUCTS COMPANY
Detroit, Michigan

Design and Construction:
The Austin Company
Electrical Contractor:
Hall Engineering Company
Electrical Distributor:
General Electric Supply Company

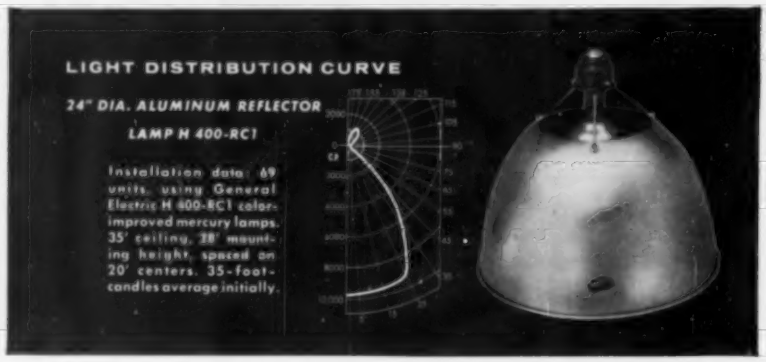
The Austin Company specified...

Abolite uplight mercury units for economical high bay lighting

Plans for this new plant called for high bay illumination without objectionable shadows between lamps and ceiling. That's why Abolite aluminum uplight mercury units were specified. The unique open-top design of this reflector provides 18% uplight, washes out ceiling contrasts, gives excellent overall illumination. Cleaner, cooler lighting, longer lamp life, less maintenance also result from the open-top feature.

You can make important savings with these new Abolite uplight mercury units. Compare their performance and cost with other type fixtures. For full details write *Abolite Lighting Division, The Jones Metal Products Co., West Lafayette, Ohio.*

ABOLITE LIGHTING


LIGHT DISTRIBUTION CURVE
24" DIA. ALUMINUM REFLECTOR
LAMP H 400-RC1
Installation data: 69 units, using General Electric H 400-RC1 color-improved mercury lamps. 35' ceiling, 28' mounting height, spaced on 20' centers. 35-foot-candles average initially.

EMPLOYMENT OPPORTUNITIES

REPRESENTATIVE WANTED

Specific territory open. Sales representative or sales organization wanted to contact architects, engineers, contractors and electrical distributors to sell nationally known commercial, industrial and institutional lighting line, meeting today's competition and tomorrow's future design. We are Holophane licensees and members of the RLM Standards Institute. Due to our new accelerated sales program, many new territories are open (protected). We have just completed our 1957 catalogue which is ready for national mailing. Kindly contact Box 277, Publications Office, Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.

DESIGNERS - DRAFTSMEN

Rapidly expanding lighting manufacturer with national distribution, offers challenging future to men with some previous experience in any of the following phases of lighting engineering and design: Fluorescent and Incandescent; Commercial and Residential; including custom chandeliers. All replies strictly confidential. Salary open. Send resume to Litecraft Manufacturing Corporation, 8 East 36th St., New York, N.Y.

LIGHTING SALES REPRESENTATIVE WANTED

Upper New York State Territory

This is a rare opportunity for an experienced lighting salesman. The territory is now active and profitable . . . our line is being specified and displayed . . . the vast potential has yet to be tapped.

If you are looking for better than average income and association with a well-respected, full line manufacturer of incandescent and fluorescent lighting . . . here's a chance to make your ability, know-how and drive pay off in a BIG way. Good service and deliveries . . . PLUS powerful promotional backing. Send full details to:

Litecraft Manufacturing Corp.
8 East 36th St., New York 16, N. Y.

LIGHTING FIXTURE SALESMEN

Established Manufacturer of Specification Quality Fluorescent Fixtures requires men with following among Distributors, Engineers, Architects.

Give experience, territory and other lines carried.

Address Box 303, Publications Office, Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.

NEW I.E.S. LIGHTING DATA SHEETS SERIES XXII

Coming Soon!

Renewals and new subscriptions for I.E.S. Lighting Data Sheets, new Series XXII, should be placed now in order to insure an unbroken series of these valuable aids to lighting promotion and sales. The new Series XXII will feature 24 outstanding lighting installations, covering several different fields, selected by a special I.E.S. Committee. For your own lighting "idea" file . . . for showing good lighting ideas to your customers . . . for mailing or other distribution to your promotion list to suggest good lighting ideas, there is no handier or more authoritative selling tool than I.E.S. Lighting Data Sheets.

Available in single or quantity subscription, 24 sheets per yearly series, distributed in lots of 8 sheets, 3 times a year; $1.25 per individual subscription; $1.00 in lots of ten or more subscriptions. Mailed anywhere. Please use the coupon below and place your order now.

Your prepayment of orders totalling $2.00 or less will greatly simplify handling and help us in our bookkeeping. Thank you.

Date _____

Publications Office
Illuminating Engineering Society
1860 Broadway
New York 23, N. Y.

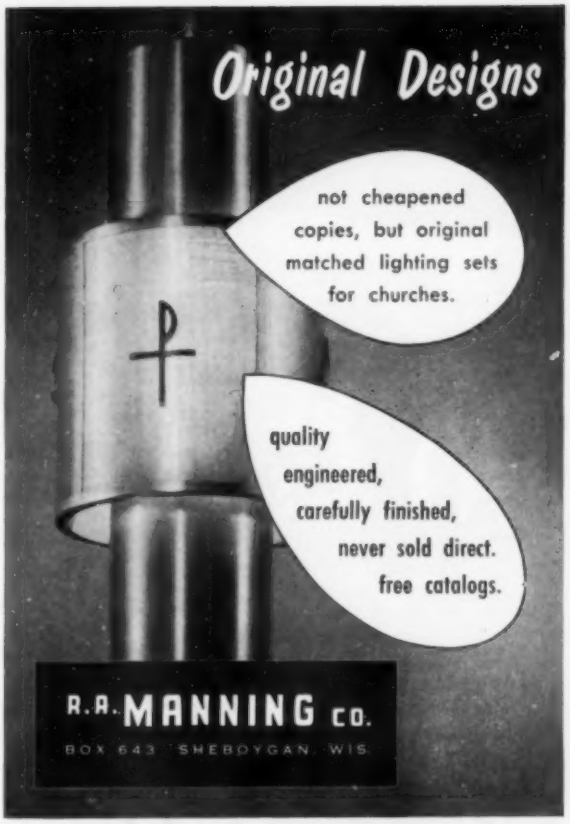
Renew } My subscription to I.E.S. Lighting Data Sheets. Send
Begin } ( ) set(s) of Series XXII at $1.25; 10 or more sets, $1.00.

Name _____

Address _____

City _____ Zone _____ State _____

☐ Check or M.O. enclosed. ☐ Bill me.


Original Designs
not cheapened copies, but original matched lighting sets for churches.
quality engineered, carefully finished, never sold direct. free catalogs.
R.A. MANNING CO.
BOX 643 SHEBOYGAN WIS.

An Inconspicuous Light Source . . .

. . . describes Wiley's new Zephyrs. Their beautiful unadorned lines harmonize so well with *any* decor that you're unaware of the source of light. Their wafer-like thinness makes them ideally suited to installations where recessed fixtures cannot be used.

They may be arranged end to end, side by side to form squares, rectangles, borders. They may be mounted flush or suspended. You may have your choice of shielding: louvered (molded one piece polystyrene grid, metal egg-crate) or glass (Corning flat or curved lens).

Erection is simple, requiring only minutes. Patented E-Z servicer simplifies maintenance. Fixtures measure 12″ x 48″ and are only 3¼″ deep. E.T.L. certified electrical components are used.

R & W WILEY INC. PIONEERS IN FLUORESCENT LIGHTING
DEARBORN AND BRIDGE STS. BUFFALO 7, NEW YORK

ever have trouble lighting a wall *Smoothly?*

KLIEGL Wall Washers will do it! Beautiful wall lighting —without scallops—now possible. Unique reflector design projects light through a small 2½" ceiling opening illuminating the wall smoothly from ceiling to floor. Straight down lighting also obtainable by simply removing interior baffle.

New, 36-page brochure, A-11-C, sent on request. Contains comprehensive architectural and engineering information on Downlights, Wall Washers, other new and different lighting equipment.

Architectural Lighting Division

KLIEGL BROS

Lighting

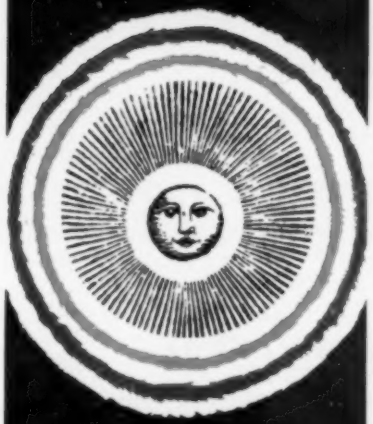
321 West 50th Street, New York 19, N.Y.

Originators and Manufacturers of Klieglights

INDEX TO ADVERTISERS
April 1957

Abolite Lighting Division Jones Metal Products Co.	56A
Advance Transformer Co.	18A-19A
Bakelite Company, Div. of Union Carbide & Carbon Corp.	38A
Brascolite Incandescent Div. Edwin F. Guth Co.	11A
Century Lighting Inc.	50A
Contrex Company	25A
Corning Glass Works	14A-15A
Curtis Lighting Inc.	5A
Day-Brite Lighting Inc.	17A
E. I. duPont de Nemours & Co. Inc.	36A
Durable Formed Products Inc.	47A
Garden City Plating & Mfg. Co.	60A
General Electric Co., Acces. Equip.	20A
General Electric Co., Apparatus	39A
Gibson Manufacturing Co.	6A
Edwin F. Guth Co.	Back Cover
Hexcel Products Inc.	45A
Holophane Co. Inc.	27A
Kliegl Bros.	58A
Kopp Glass Inc.	31A
Light & Power Utilities Corp.	51A
Litecontrol Corp.	43A
R. A. Manning Co.	57A
McPhilben Lighting Co.	52A
Metalcraft Products Co. Inc.	32A
Novelty Lighting Corp.	55A
Perfeclite Company	37A
Pfaff & Kendall	44A
Photo Research Corp.	54A
Rambusch Decorating Co.	46A
Revere Electric Mfg. Co.	59A
RLM Standards Institute	Inside Back Cover
Rotuba Extruders Inc.	28A
Sheffield Plastics Inc.	53A
Smithcraft Lighting Div.	1A
Sola Electric Co.	12A
Starring & Company Inc.	2A
Sunbeam Lighting Co.	41A
Superior Electric Co.	49A
Sylvania Electric Products Inc.	23A, 40A
Union Metal Mfg. Co.	35A
Kurt Versen Company	59A
Vickers Electric Division Vickers Incorporated	42A
Wakefield Company	Inside Front Cover
Westinghouse Electric Corp., Lamps	4A
R. & W. Wiley Inc.	57A

THE ONLY FIXTURE THAT OUTPERFORMS KURT VERSEN



....but Kurt Versen fixtures do offer the advantages of glare-free illumination where and when you want it, with less heat and with uniform light distribution. For controlled lighting, masterfully engineered for simplified low cost installation and trouble-free service, Kurt Versen units are the best buy under the sun.

They're competitively priced.

Write for our catalog.

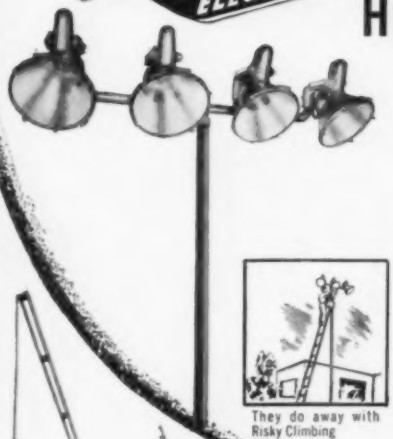
kurt Versen
company
contemporary lighting
Englewood 7, New Jersey

TODAY more than ever—

Revere
ELECTRIC MFG. CO. CHICAGO, U.S.A.

HINGED POLES

Remain Unsurpassed in UTILITY and EFFICIENCY



They do away with Risky Climbing

They eliminate expensive elevating equipment

Save dollars because Floodlights can be serviced from ground

The Greatest Boon to Easy Maintenance — and, easy maintenance promotes more frequent cleaning of Floodlights

199-E Square Tapered Pole in 20', 24' and 30' mounting heights

300 Series Round Pole in 20' and 24' mounting heights

800 Series Street Lighting Type in three mounting heights

Cor-Ten Heavy-Duty Pole will handle 180 lbs. of Floodlights

A Revere First

Introduced over 25 years ago

— and, more desirable today when competition demands highest efficiency in outdoor lighting.

THE PATENTED WIRING ARRANGEMENT THROUGH THE HINGE PIN on which the success of **REVERE HINGED POLES** is based. Note: Wire lays flat when Pole is down— no perceptible movement of wires.

Write for Literature

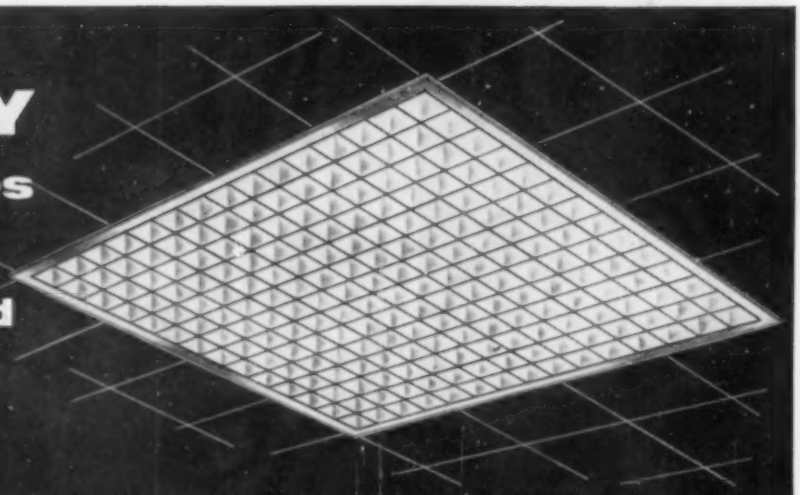
REVERE ELECTRIC MFG. CO. • 6009-17 BROADWAY • CHICAGO 40, ILL.

Available in Canada thru Curtis Lighting, Ltd., Leaside, Toronto, Ontario

THE ONLY COMPLETE LINE OF LUMINAIRES • FLOODLIGHTS AND POLES FOR STREET • SPORTS AIRPORT • SERVICE STATION • OUTDOOR THEATRE • MARINE AND INDUSTRIAL LIGHTING

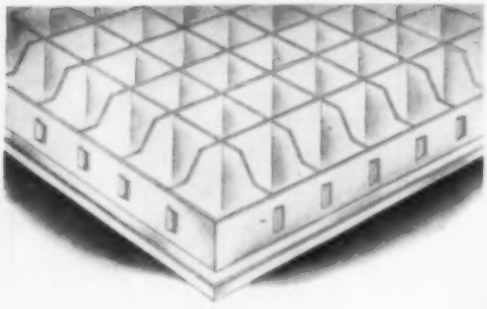
GARCY

5600 series 4′ x 4′ Recessed Lighting



Lightweight one-piece louver
reduces fixture weight . . . adds strength

No Wavy Lines

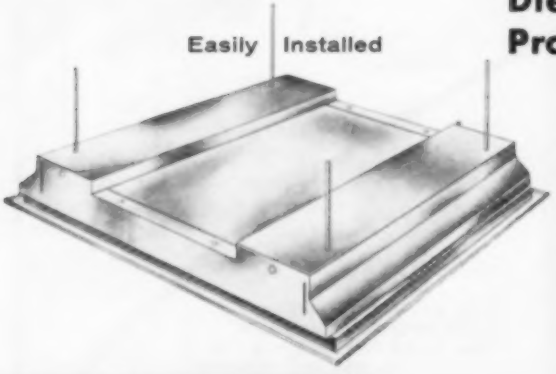


Unique One-Piece Framed Louver Cannot Sag or Lose Its Shape

Interlocking aluminum fins are rigidly locked into hinged frames. The total weight of this large area fixture is reduced by 25% imposing less burden on the ceiling.

Louvers cannot twist or bend out of alignment . . . no unsightly wavy lines. Small cell size provides soft, even lighting. Lamp placement in relation to louver fins assures even brightness, ample shielding.

Easily | Installed

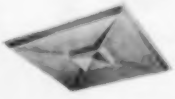


Die-Formed, Twin-Channel Housing Provides Greater Rigidity

Extra forming means greater rigidity without extra weight. The ballasts are located in channels. Heat from the ballasts is more efficiently dissipated because of the greater surface area provided.

Ease of installation is assured . . . hinged frames fit precisely . . . trim flanges fit snugly against the ceiling. Other sizes: 2′x 2′, 2′x 4′, 2′x 8′.

Send for Bulletin 552-L.



Also available with one-piece plastic shield.

GARCY
Preferred for Performance
COMPLETE COMMERCIAL LIGHTING

Garden City Plating and Manufacturing Company
1760 North Ashland Avenue • Chicago 22, Illinois
In Canada: Garcy of Canada, Ltd., 1244 Dufferin Street, Toronto 4

1,000 WORDS of Specifications covering:
RLM 48" & 96" Two-Lamp
Direct Fluorescent Porcelain Enameled
Units with 8%-15% Upward Light

1,000 WORDS of Specifications covering:
RLM 48" & 96" Three-Lamp
Direct Fluorescent Porcelain Enameled
Units with 8%-15% Upward Light

1,000 WORDS of Specifications covering:
RLM 60" Two-Lamp
Direct Fluorescent Porcelain Enameled
Units with 8%-15% Upward Light

1,000 WORDS of Specifications covering:
RLM 48" & 96" Two-Lamp
Semi-Direct Fluorescent Porcelain Enameled
Units with 20%-30% Upward Light

1,000 WORDS of Specifications covering:
RLM Dome Porcelain Enameled Reflectors

1,000 WORDS of Specifications covering:
RLM Deep Bowl
Porcelain Enameled Reflectors

1,000 WORDS of Specifications covering:
RLM Symmetrical Angle
Porcelain Enameled Reflectors

1,000 WORDS of Specifications covering:
RLM Porcelain Enameled Reflectors
for High Mounting

1,000 WORDS of Specifications covering:
RLM Glassteel Porcelain Enameled Diffusers

1,000 WORDS of Specifications covering:
RLM Aluminum Reflectors for High Mounting

latest RLM® book yours without cost!

contains 10,000 Words of Specifications

Covering the HIGHEST Industrial LIGHTING STANDARDS in RLM History!

From incandescent to fluorescent . . . from porcelain enameled Dome Reflectors to latest 20—30% Upward Light porcelain enameled fluorescents . . . these RLM Specifications are the highest in history! In fact, today's RLM minimum standards are higher from both important standpoints: *quality construction*, as well as *quality lighting*. That is why the RLM Label on lighting equipment today is the buyer's assurance of outstanding industrial lighting advantages such as are listed here.

For each RLM-labeled unit it takes over a thousand words of quality specifications to cover the basic, nationally-accepted minimum standards for efficiency, performance and basic construction. In all, there are 10 types of industrial lighting units for which RLM Specifications have been developed. With each specification running over 1,000 words, that makes a total of over 10,000 words of specifications! You'll find them all in the latest RLM Specifications Book. For your complimentary copy, use the coupon or write: RLM STANDARDS INSTITUTE, Suite 823, 326 W. Madison St., Chicago 6, Ill.

Highest Industrial Lighting Standards in RLM History assure these advantages:

Higher light output • Lower-cost installation
Better protection against glare
More seeing comfort • Easier re-lamping
Increased brightness control
Reduction of light loss
Safety from electrical hazards
Protection against rust and corrosion

RLM STANDARDS INSTITUTE
INCORPORATED
The letters RLM stand for Reflector and Lighting Equipment Manufacturers

RLM Standards Institute, Suite 823, 326 W. Madison St., Chicago 6, Ill.
Please send free RLM Specifications Book.

Name.....

Address.....

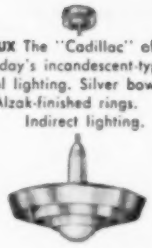
City.....Zone.....State.....

RC-1552

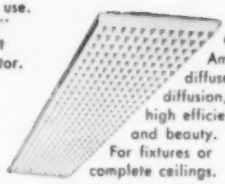
SUPER-ILLUMINATOR Sparked "Better Light-Better Sight" campaign of the Thirties. Provided totally indirect luminous bowl lighting

BRASCOLITE "King of Night" Millions sold world-wide from 1912-22. Thousands still in use. First "engineered" light fixture with first porcelain-enameled reflector.

SEELUX The "Cadillac" of today's incandescent-type school lighting. Silver bowl lamp. 3 Alzak-finished rings. Indirect lighting.



GRATELITE Louver Diffuser* Amazing ⅜" cubicle "louver diffuser" for excellent diffusion, low brightness, high efficiency and beauty. For fixtures or complete ceilings.



GUTH-GL Invented create natural lighting railroad dining ca Mounted between windows.

ARISTOLITE Unique floating hinge gives open-fixture cleanliness with glass panel diffusion. Drop panels —easier to clean from floor.

CADET LUMINAIRE 6,600 installed at West Point. 85% efficiency (best efficiency for this type lighting).

OPTILUX Totally enclosed indirect school luminaire. Kids couldn't throw spitballs into 'em!

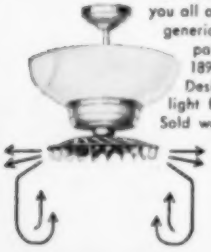
DIAGONAL SPECTRAL ASSIMILATION For mercury vapor and incandescent lamps in combination . . . commercial and industrial uses.

WAR-TIME MAZELITE Ingenious design utilized 3# steel channel (maximum allowed per fixture by WPB during World War II). Masonite reflector completed unit.

NITE-LITE Porcelain night light with 6-volt transformer. (Used before today's miniature bulbs.)

AGLITE Bathroom bracket. Biggest seller of roaring Twenties. Porcelain holder in 100 varieties.

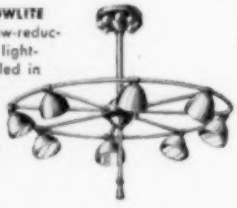
GUTHFAN "Cools you all over." First generic fan patented between 1898 and 1929. Designed with light fixtures. Sold world-wide 1929-38.



BDHIC "Best Darned Holder In (The) Country." Four-point safety holder.

STACK-LITE First engineered patent aisle light. For illuminating stacks, bins, shelves, etc

NO-SHADOWLITE First "shadow-reducing" surgery light-fixture. Installed in thousands of hospitals during the 1920's.



GUTH-LITE Porcelain reflector over opal globe with reflector apertures for ceiling lighting. Thousands sold 1925-29.

55 years of lighting history

written by the creative mind of Edwin F. Guth, Sr.

Shown here are a few of the more than 160 patented lighting devices invented by Edwin F. Guth, Sr.—a pioneer whose devotion to better lighting has inspired an entire industry.

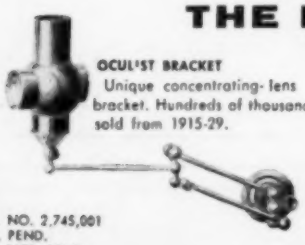
His company, now celebrating its 55th Anniversary, has been a leader in lighting since 1902.

JACKNIFE Exclusive hinge feature for relamping and cleaning from floor. Best low-cost maintenance Fluorescent.

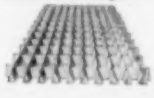
THE EDWIN F. GUTH CO. ST. LOUIS 3, MO.

TRUSTED name in lighting since 1902

OCULIST BRACKET Unique concentrating-lens bracket. Hundreds of thousands sold from 1915-29.



PRISMOID GRATELITE** Ready soon. Beautiful new crystal-like reversible "louver-lens". (Combines advantages of both.)



REFLECTOR FLANGE Porcelain enamel globe holder with one-spring mechanical release. Hundreds of thousands sold.

*® U. S. PAT. NO. 2,745,001 CAN. PAT. PEND.
** T. M. AND PATS. PEND.